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WARREN'S

STABILIZED NATURAL GASOLINE and STA-VOL-ENE

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Crude Oil, Natural Gasoline and Liquefied Petroleum Products

8-hour job now takes 4 hours

At a western magnesium reduction plant something besides magnesium has just been reduced. The steam at the end of the 1½ mile long steam line wasn't so hot—and neither was the production record of the plant at that location.

Then 26 old-type steam traps were replaced with Yarway Impulse Traps. Now there is only a 15° temperature drop from the boilers to the end of the line. *Most important, the plant 1½ miles from the boilers is now able to do work in 4 hours that previously took 8 hours.*

That's trap efficiency! It's evidence of the fact that Yarways are designed to send the most premium B.T.U.'s at top temperatures into your process or product. *They get equipment hotter, sooner . . . and keep it hot.*

Other Yarway features—small size, one moving part, easy installation, low maintenance, low cost, stainless steel construction. Nearly 750,000 Yarways have already been installed. For your Yarways, see a nearby industrial distributor . . . 216 stock and sell Yarways.

YARNALL-WARING COMPANY, 128 Mermaid Ave., Philadelphia 18, Pa.

FREE TRAP SELECTOR

It's important to have the right trap in the right place. New 20-page selector tells quickly and easily which *is* the right Yarway trap for any application. Write for your free copy.

YARWAY

the steam trap

designed with more production in mind

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Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

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VOLUME 30, NO. 12 — DECEMBER, 1951

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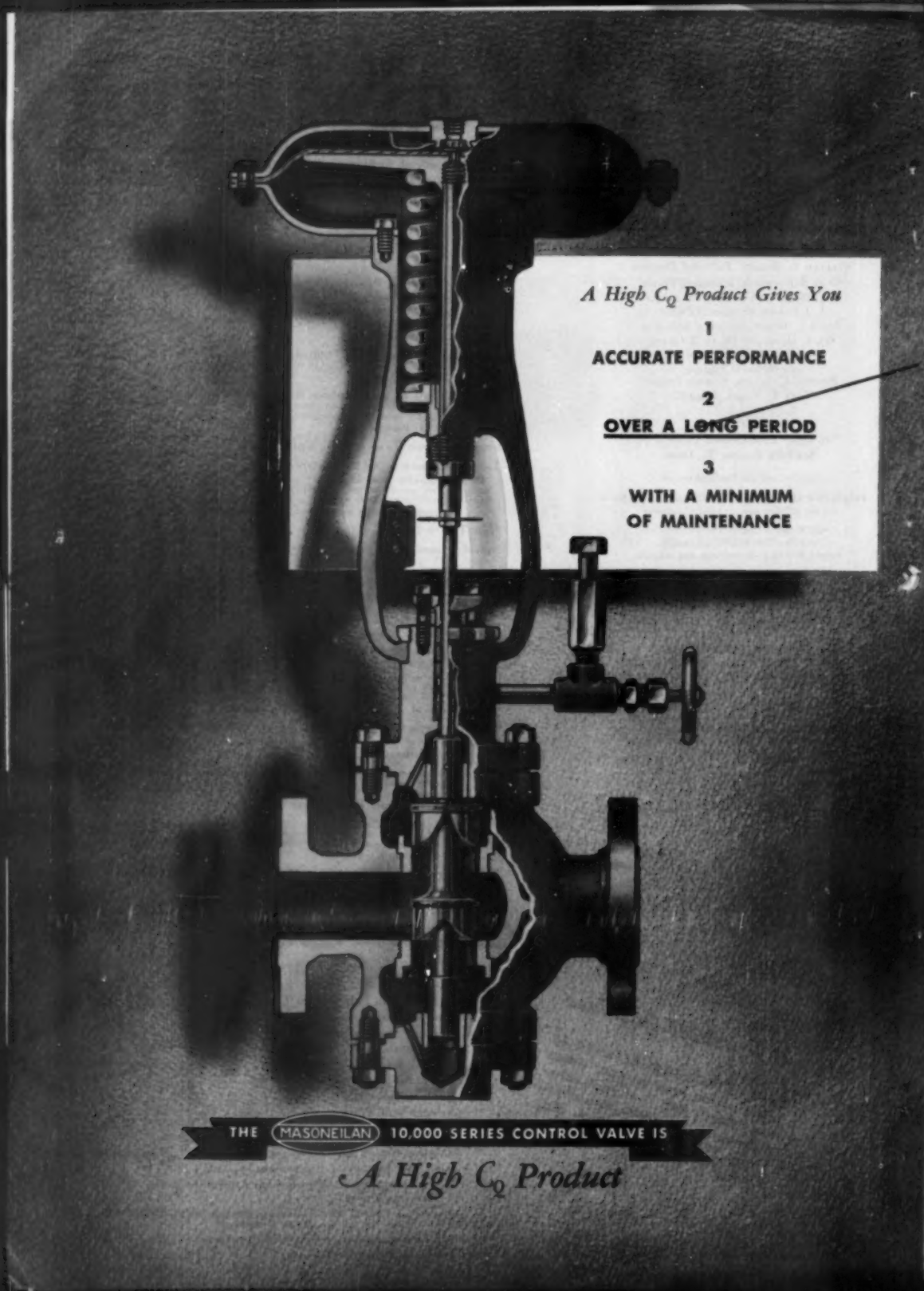
A High C_Q Product Gives You
1
ACCURATE PERFORMANCE
2
OVER A LONG PERIOD
3
WITH A MINIMUM
OF MAINTENANCE
THE MASONEILAN 10,000 SERIES CONTROL VALVE IS
A High C_Q Product

Accurate Control Valve Performance Over a Long Period Requires

Stamina

While ACCURACY is the No. 1 Quality Factor in Control Valve Performance, you get your money's worth only from a valve which you can depend on to give you accurate performance *over a long period;* one which is built with foreknowledge of the severe conditions under which it may have to operate and which is designed to stand up under those conditions. In Masoneilan Control Valves — this "money's worth" doesn't just happen. It is the product of long years of experience skillfully applied.

Here is how Masoneilan Control Valves are designed and built to assure this stamina

Over-all Strength

Cast iron yoke and enclosed spring barrel of heavy cross-section, rigidly attached by large diameter forged steel drive nut to one piece steel bonnet, which is in turn heavily bolted to the body, make up a superstructure which will not deform in rough handling to cause misalignment.

Strength of Individual Parts

Steel Diaphragm Case combines lightness, high mechanical strength and high safety factor in case of severe over-pressuring.

Spring Stem — Steel Diaphragm Button Welded Assembly assures continuous service even under conditions of excess line vibration.

Heavy Springs for low stress — retain exact calibration for an indefinite period.

Bolted Stuffing Box on sizes 2" and larger; on smaller valves threaded construction has 5-thread minimum engagement; insures enduring safety. Lubricator is ¼" NPT size minimum.

Large Diameter Spring and Valve Stems directly threaded together without adapters (plus Keylock on sizes 3" and up) provides strongest construction.

Stem-to-Plug Fastening threaded and pinned by means of grooved, self-locking pin; special method of pinning insures tightness, prevents shearing.

Heavy Plug and Guide Sections insure strength for the severe applications.

Piloted Seat Rings with heavy shoulders and long threaded section plus narrow seating surface in bridge wall prevents distortion and assures tight joint.

Piloted One-piece Bonnet and Blindhead heavily bolted to body.

Fully Retained Gaskets of corrugated armco iron or special alloys for tightness and durability.

Corrosion Resistance

Diaphragm case Parkerized inside and out, then painted; yoke, spring case and body assembly, painted; springs treated to resist rust; all trim parts made of stainless steel.

Selection of Materials for special operating conditions includes variety of body materials; special alloy trim; plugs and seat rings heat treated and/or faced for erosion resistance; variety of packing materials and lubricants.

In selecting control valves consider *all* the quality factors — the factors which insure accurate performance "for a long period," with a minimum of maintenance. For the sum of *all* the quality factors is the Quality Coefficient (C_Q) and in comparing cost, remember that *real* cost includes invoice price *plus* cost of maintenance and down-time. Thus among comparably priced valves the best buy is the one with the highest Quality Coefficient. For

$$\text{Real Cost} = \frac{\text{Price}}{C_Q}$$

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How to get the most from your high temperature tubes: Ask the experts!

CHANCES are you can find several high temperature steels that will solve your heat, pressure, corrosion and oxidation problems. But there's only *one* steel that will give you maximum tube life per dollar —the best life/cost ratio.

The Timken Company metallurgists—the recognized authorities on high temperature steels—can help you find that one steel. With a background of 20 years of steel development and with 23 different analyses at their disposal—plus wide field experience—they are qualified to help you choose the correct analysis for your application. And whatever analysis is recommended, you can be sure of uniform quality because the Timken Company carefully controls quality from melt shop through final inspection.

Our "RSQ"—Research, Supply, Quality —can solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

The Timken Company pioneered in testing high temperature steels. Hot twist apparatus shown here is used to evaluate the hot working characteristics of high temperature steels.

This month's report is on: **4-6% CR.-MO.**

Suggested for applications where high creep resistance is not required, but where good stability, corrosion and oxidation resistance are essential. For cracking furnace tubes, heat exchangers, super-heaters, air heating equipment and forgings and other parts exposed to oxidation or oil corrosion.

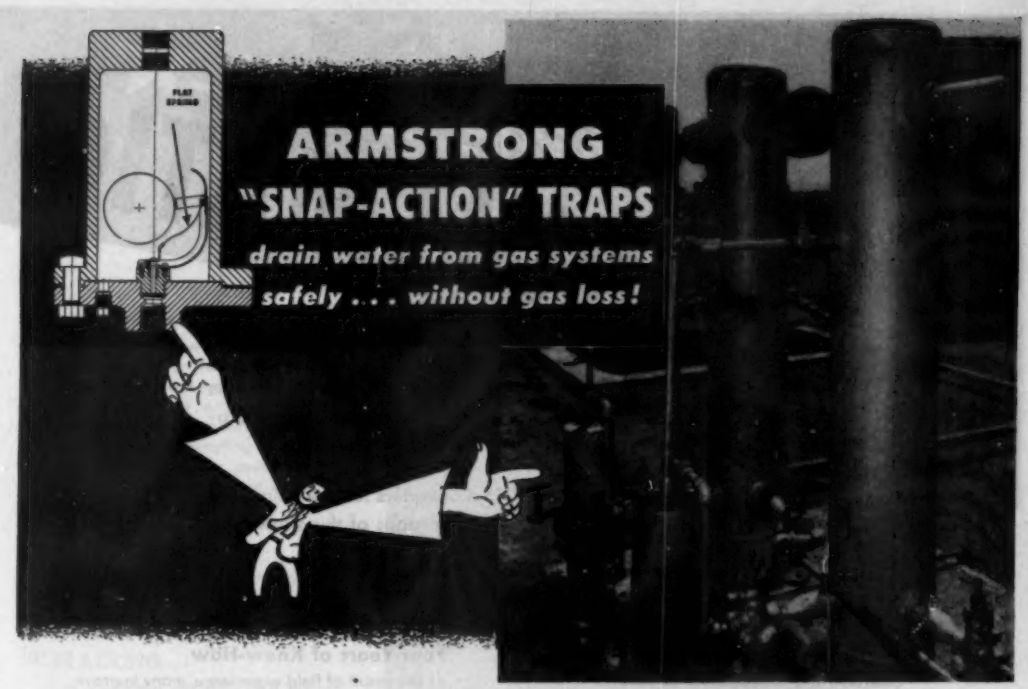
23 TIMKEN STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 3	Sicromo 9M	35-19*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

**Not available as seamless tubing at the present time.*

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing



No. 71-315 Snap-Action Traps used in California to drain water from gas scrubbers.

Use Them for Draining Scrubbers, Separators, Drip Pockets, Aftercoolers

HERE'S a dependable, positive-acting trap: when sufficient water accumulates in the trap to float the ball and overcome the tension in the bowed flat spring shown in the drawing above, the spring snaps the valve wide open. As water shoots out the float drops, bending the spring until it snaps the valve shut. Thus, with the valve either wide open or tightly closed there is no hunting or dribbling nor will fine dirt particles prevent the valve from seating tightly. You get fast, automatic drainage with no gas loss. These traps have been widely proved in gas system and compressed air service. Ask your local Armstrong Representative for additional details and prices on the No. 71-315 trap.

- **FORGED STEEL...for safety at pressures to 1000 lbs.**
- **SPRING-POWERED VALVE ACTION . . . eliminates dribbling, hunting and leaking.**
- **HARDENED CHROME STEEL VALVE AND SEAT... insure maximum wear resistance and long life.**
- **STAINLESS STEEL TRIM . . . protects against corrosion.**
- **LARGE CAPACITY . . . 585 lbs/hr at 400 psig, 840 lbs/hr at 1000 psig—meets nearly all drainage loads.**
- **GUARANTEED PERFORMANCE . . . the same famous "satisfaction or money back" guarantee that covers every Armstrong Inverted Bucket Steam Trap.**

SEND FOR CATALOG

New 12 page condensed catalog gives latest data on all Armstrong Traps. Ask for a copy.

ARMSTRONG MACHINE WORKS
852 Maple Street • Three Rivers, Michigan

ARMSTRONG GAS TRAPS

Let's look at the performance of

The NULLMATIC Controller was a new development in 1947. Its friction-free operation set new standards for control instruments.

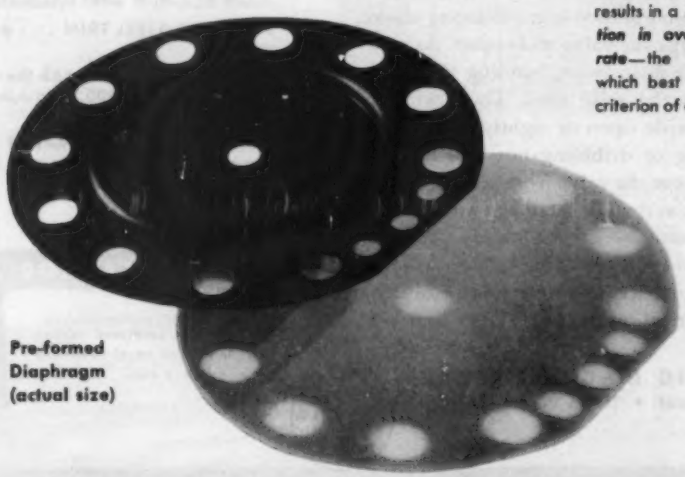
Now—*four years and 4315 Controllers later*—users here and abroad have proved the advantages of this stack-type design.

Pneumatic Force-Balance Operation
Controller lag is practically eliminated.

Simplicity of Field Maintenance
Diaphragms will withstand 100 psi. The pilot valve, restrictions, and needle valves—the only other working parts—can be removed easily, for cleaning.

Four Years of Know-How
As the result of field experience, many improvements have been made since the first production units—although *these first Controllers are still operating continuously.*

Now, the performance is further improved by the use of pre-formed diaphragms in the throttling unit. This major advancement in design results in a ***50% reduction in over-all spring rate***—the one factor which best serves as a criterion of over-all performance.



Pre-formed Diaphragm (actual size)

MOORE PRODUCTS CO., PHILADELPHIA 24

ALL NULLMATIC Controllers meet the following performance specifications: (These values are conservative—the results of tests on standard production instruments, using 3 to 15 psi operating range and 25 psi supply pressure. Many tests have shown even better values.)

★ **RESPONSE LEVEL**

The output is sensitive to changes in the measured variable—as small as 0.01% of full range.

★ **TRACKING**

The measured variable and the control point align within 0.5% of full range.

★ **REPRODUCIBILITY OF OUTPUT**

—within 0.3% of full range.

★ **AIR CONSUMPTION**

—0.2 scfm (in balance, on dead-end service).

★ **OUTPUT CAPACITY**

—up to 3 scfm.

Send for this New Catalog

Bulletin 5011 contains additional performance data and complete information on NULLMATIC Controllers, M/P Control Stations, Derivative Units, and M/F Relays for interlocking control circuits.

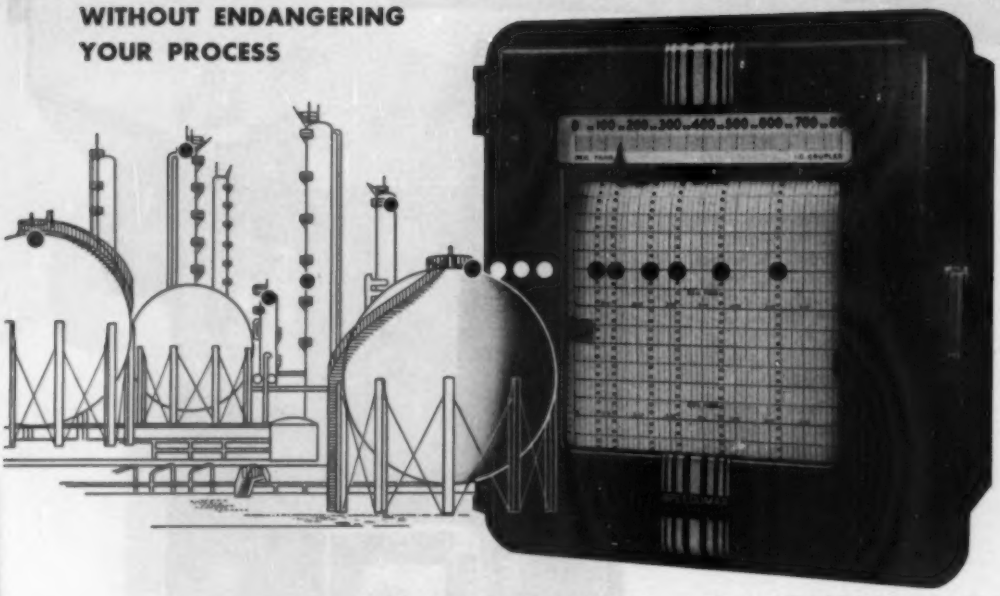
Model 50—Remote Set Type

Branch Offices: CHICAGO, DETROIT, HOUSTON, LOS ANGELES, PITTSBURGH

Subsidiaries: Moore Instrument Co., Ltd., TORONTO
Air Clocks, Inc., HUNTINGTON STATION, N. Y.

HOW TO CENTRALIZE OPERATING DATA *and save money*

WITHOUT ENDANGERING YOUR PROCESS



In as little time as 2 seconds per point, Speedomax Multiple-Point Recorders centralize data about temperatures or other conditions scattered throughout process units.

Centralizing operating data from process units on one recording instrument pays off. It saves panel space. It lowers the recording cost per point. It warns of upsets in ample time for your men to act. It does all this . . . IF the instrument checks operating conditions frequently enough—fast enough.

With Speedomax Multiple-Point Recorders, you get not only the inherent savings in centralized data, but maximum information about critical process operations. At the fast rate of 2 seconds per point (or 3 or 4 seconds, if preferred), they can whip through as many as 16 or 20 similar variables in as little as 32 or 40 seconds. Where an extremely critical variable is involved, that point can be recorded more frequently than the others —in the sequence of 1, 2, 1, 3, 1, 4, 1, 5, etc.

In addition to this recording speed, other features give superior performance. A soundly-designed amplifier and electronic circuit assure unusual accuracy and sensitivity over range spans as narrow as 100 F. Instrument performance is unaffected by vibration. The quantity measured may be temperature, pH, speed, weight or electrical load.

The next time you want to bring temperatures or other data to a central point, make sure you do it safely . . . by getting the speed you need to guard against sudden upsets. Specify Speedomax Multiple-Point Recorders. For additional information about these instruments, just check the coupon and return.

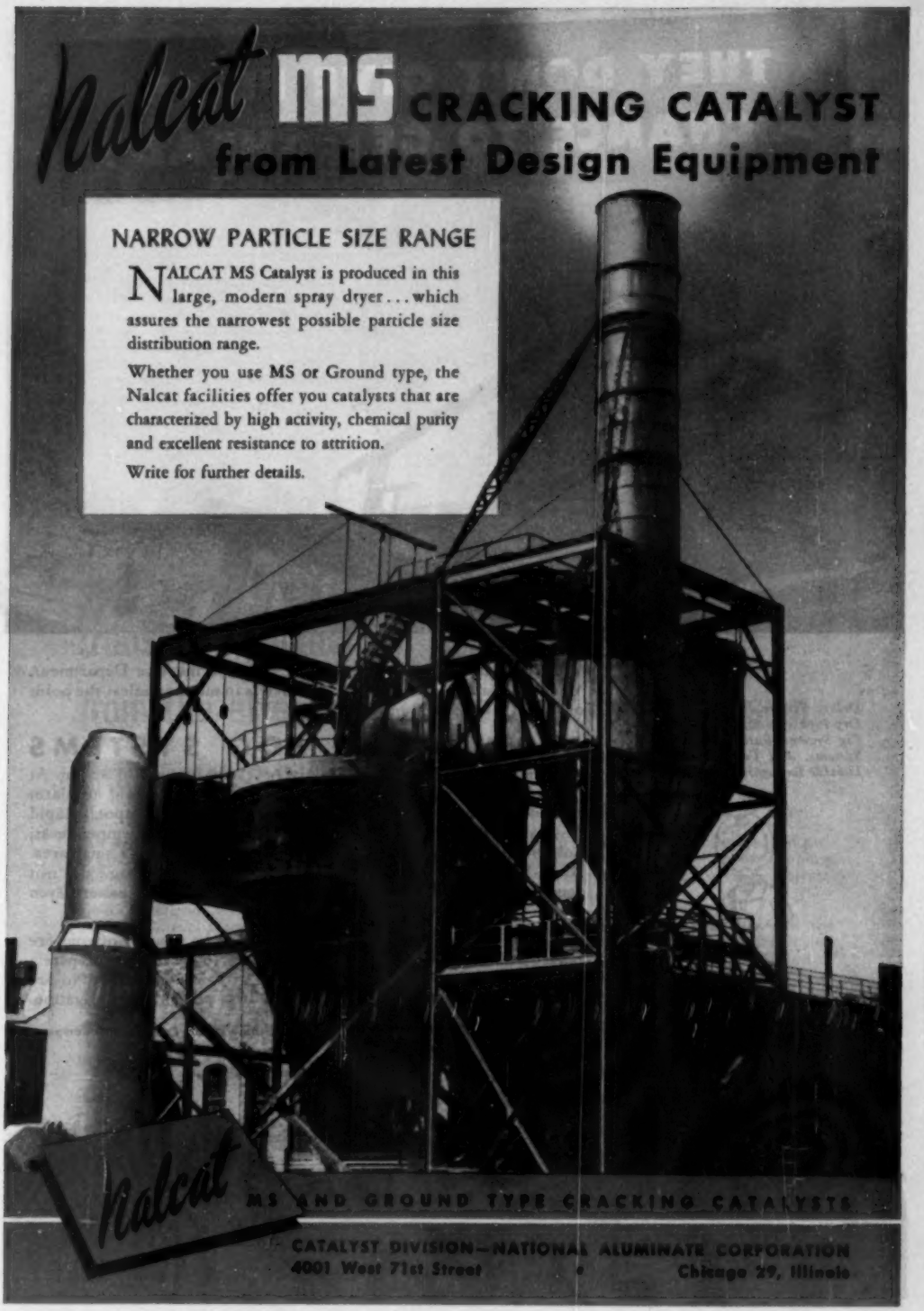
LEEDS & NORTHRUP CO.

LEEDS & NORTHRUP CO.
4923 Stenton Ave., Phila. 44, Pa.

Please send Speedomax Catalog ND46.
Please send information about applying Speedomax Multiple-Point Recorders to

(Name) (Title)
(Firm)
(Address)

Ad. Ad ND46-700(1)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Deluge Systems, Wet Pipe Systems, Dry Pipe Systems, Water Spray and Fog Systems, Rate-of-Rise Sprinkler Systems, and Foam and Carbon Dioxide Extinguisher Systems.

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Always on the job

Volatile liquids, once ignited, don't wait for the Fire Department. You'll have a raging inferno on your hands in minutes unless the point of origin is quenched in seconds.

BLAW-KNOX FOG SYSTEMS

with rate-of-rise thermostats are always ready for instant action. At the first indication of dangerous temperatures they sound an alarm and start a dense, quenching fog of water to the "hot spot." Rapid dissipation of heat prevents the development of high temperatures, possible bursting pressures, and confines the damage to a small area. Blaw-Knox Fog Nozzles have no screens to clog, do not require treated water and maintain their effective spray pattern even at reduced pressures.

At your request a Blaw-Knox Engineer will make a survey of your fire hazards, secure your insurance underwriter's requirements, prepare a preliminary layout of a system that will give you the utmost in fire protection, and submit an estimate of costs—all without obligation.

BLAW-KNOX SPRINKLER DIVISION of Blaw-Knox Construction Company
829 Beaver Ave., N.S., Pittsburgh 33, Pa.
Offices in Principal Cities

Blaw-Knox AUTOMATIC FIRE PROTECTION SYSTEMS

High-level reactor exchanger built for one of the world's largest Ethanol plants, showing copper-lined channel and removable copper pass rib with unusual reinforcement designed to give support against high pressure drop at elevated temperatures.

How A.O.Smith protected heat transfer equipment from the effects of Phosphoric Acid Corrosion and Hydrogen Diffusion

The problem was solved for Stone & Webster Engineering Corporation of Boston, engineers and designers of the Chemical Project of the British Petroleum Chemicals, Ltd., at Grangemouth, Scotland, with this deoxidized copper-lined, high-level reactor exchanger.

Our metallurgical laboratories ran tests on various materials in collaboration with Stone & Webster Engineering Corporation and Shell Development Company, the process licensor, which aided them in establishing deoxidized copper as the most suitable material for the protective lining.

Our welding laboratories then determined procedures to be used in the shop for welding copper to copper, copper to steel, and silver-soldering copper to steel.

Combining all laboratory assistance with the experience of the A. O. Smith heat transfer and mechanical design groups made production of this unit possible.

A. O. Smith has been retained as consultants on today's most complex heat transfer problems and the facilities employed in solving them are available to you.

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FISHER Offers You The and Complete Line

TYPE 57T

Diaphragm motor valve equipped with Fisher Positrol valve positioner.

Features:

1. Large superstructure for power to overcome friction losses.
2. Fisher Teflon V-Ring Packing requires no lubrication.
3. Wall sections and boltings conform with ASA code.
4. Yoke mounting boss for valve positioner.
5. Quality controlled materials and workmanship.

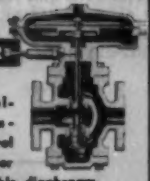
TYPE 530

High rangeability diaphragm control valve for small flows and high pressure drops commonly encountered in experimental and pilot plant operations.

TYPE 567

Reverse action topwork, generally used with push-down-to-close valves which must be spring closed in action.

TYPE 790R



Pressure balanced diaphragm control valve — either single or double diaphragm construction — for use with remote mounted instrument or pressure loader.

TYPE 57T-D

High pressure diaphragm control valve. Available in small sizes for 3,000 lbs. and 6,000 lbs. working pressure.

FISHER TEFLON V-RING PACKING

- No gland leakage.
- Used on wide range of pressures without appreciable change in friction values.
- Elimination of maintenance and adjustment.
- No valve stem lubricators required.
- Chemically inert to all fluids up to 450° F.

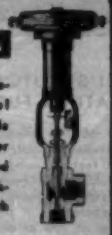
FISHER LEADS THE INDUSTRY

Industry's Most Versatile of Diaphragm Motor Valves

Illustrated here are just a few of the complete line of Fisher Governor Company diaphragm motor valves. They are manufactured to handle pressure conditions up to 10,000 pounds, for high pressure drops, for handling contaminated fluids (coke, sludge, slurry). Available in metals for highly corrosive service and alloys for high temperature work. They are built for your specific requirements with a wide choice of inner valves to provide desired flow characteristics.

TYPE 57T-DA

High pressure diaphragm control valve. Available in small sizes for 3,000 lbs. and 6,000 lbs. working pressures with angle body.



TYPE 5700

Springless type diaphragm motor valve, double diaphragm actuated. Power actuator suitable for up to 5,000 lbs. unbalanced thrust.

TYPE 1657S

Three-way diaphragm motor valve with single disc, double seat, commonly used on flow diversion work.

TYPE 57T-K

Diaphragm motor valve with fully balanced inner valve with soft seat for tight closure.

TYPE 510S

Diaphragm motor valve with small single seated bronze body.

TYPE 461-462

Diaphragm motor valve with Sweep-Flo angle body and continuous connected handwheel diaphragm motor operator.

TYPE 7700

Diaphragm motor valve with butterfly valve construction for handling large volumes under low pressure drop conditions.

TYPE 581

Diaphragm motor valve, single seated, piston balanced with internal pilot.

TYPE 57T-L

Single seated, flapper check for low pressure drop installations such as meter runs.

TYPE 1657T

Three-way valve, double port, double disc, full throttling.

TYPE 57Q

Diaphragm operated single seated body, reversible without additional parts.

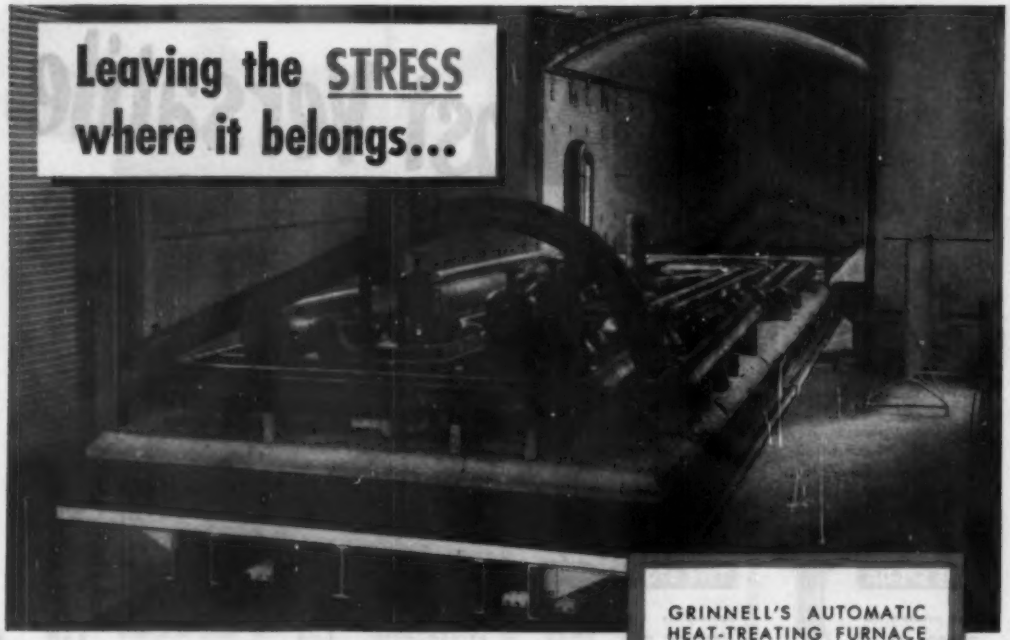
TYPE 57T

Standard diaphragm motor valve, available with variety of inner valve constructions.

FISHER GOVERNOR COMPANY, Marshalltown, Iowa

IN RESEARCH FOR BETTER PRESSURE CONTROL

Leaving the STRESS where it belongs...



Stress relieving prefabricated piping with highly developed equipment and special techniques is one reason why exacting specifications are met with

GRINNELL PREFABRICATED PIPING

Grinnell received an order recently for stress relieving prefabricated piping to these specifications:—

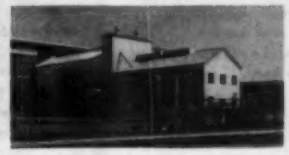
> "All fabricated pieces shall be normalized and drawn by heating to a uniform temperature of 1700°F (plus or minus 25°F). This temperature shall be maintained on a basis of one-half hour for each quarter inch of wall thickness of the heaviest pipe in the furnace charge followed by air cooling not less than 600°F. All pieces shall then be reheated to 1425°F and held at temperatures as above. In no case shall the time be less than 2 hours . . . Cool at a controlled rate not to exceed 200°F per hour until 600°F is reached . . ."

Grinnell, of course, met these specifications precisely. In fact, fabricating industrial piping today demands the *maximum* in versatility and precision.

Modern power plants, for example, need piping of heavy cross-sectional area and definite alloy composition to provide high temperature stability, resistance to creep and graphitization. Chemical and oil refining processes, on the other hand, must have piping of high chrome alloy to impart strength at high temperatures, resist corrosion, withstand impacts at low temperatures. Heat-treating often is the only answer — either to restore properties affected during fabrication, or improve original properties.

GRINNELL'S AUTOMATIC HEAT-TREATING FURNACE

performs with positive efficiency. This versatile stress-relieving unit, measuring 12 by 12 by 40 feet and using gas or oil or both as fuel, was designed to give full program control for the entire range of working temperatures. It provides instrument control of rate of rise in temperature of the charge, length of time for holding at the predetermined temperature level, and cooling rate. Two recording controllers are provided for the furnace and a separate 6-point recorder registers the temperatures of the charge simultaneously during the treating cycle.



Exterior View of Building

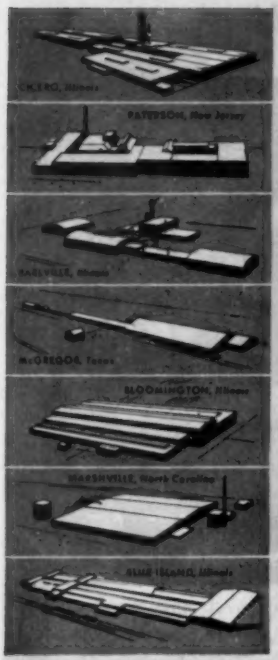
In heat-treating, as in everything else for piping, Grinnell has the experience and the costly equipment to fully protect large piping expenditures. That is why it will always pay you to call on Grinnell for *all* of your piping needs.

GRINNELL

WHENEVER PIPING IS INVOLVED

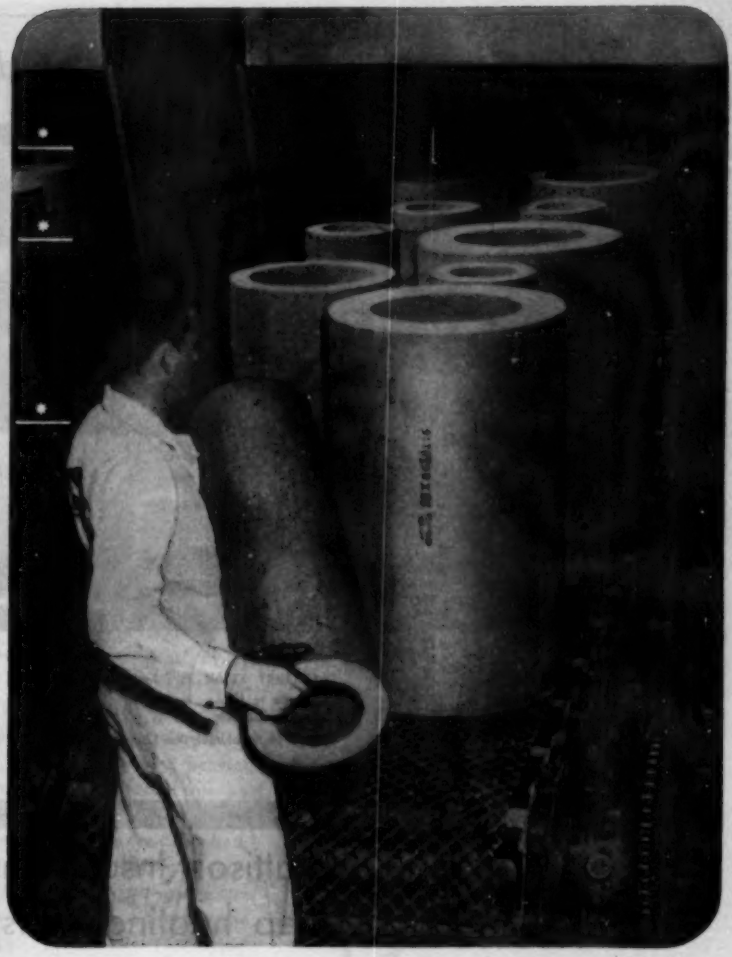
Grinnell Company Inc., Providence, Rhode Island • Sales Offices and Warehouses in Principal Cities

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco humidification and cooling systems



7 plants serve many industries' needs for . . .

- PIPE INSULATION
  Amocel
  Unibestos No. 750
  Unibestos No. 1200
- UNIBESTOS INSULATING BLOCK
- UNARCO METAL FACED INSULATING BLANKETS
- INSULATIONS . . . TAILORED-TO-FIT
- SEWN AND CEMENTED INSULATING BLANKETS



EVER BETTER INSULATION SO THAT INDUSTRIES CAN

Save Btu's on pipes of peace or war

Whatever your insulation problem, whether it is to retain heat or cold; whether it is a conventional pipe application or a unique or complicated condition involving close quarters and the need for the most rugged construction, Unarco has a type of insulation to help you meet the problem most efficiently and economically. Unarco engineers utilize the best material for the job with many exclusive Unarco construction features that have made these insulations a standard in industry.

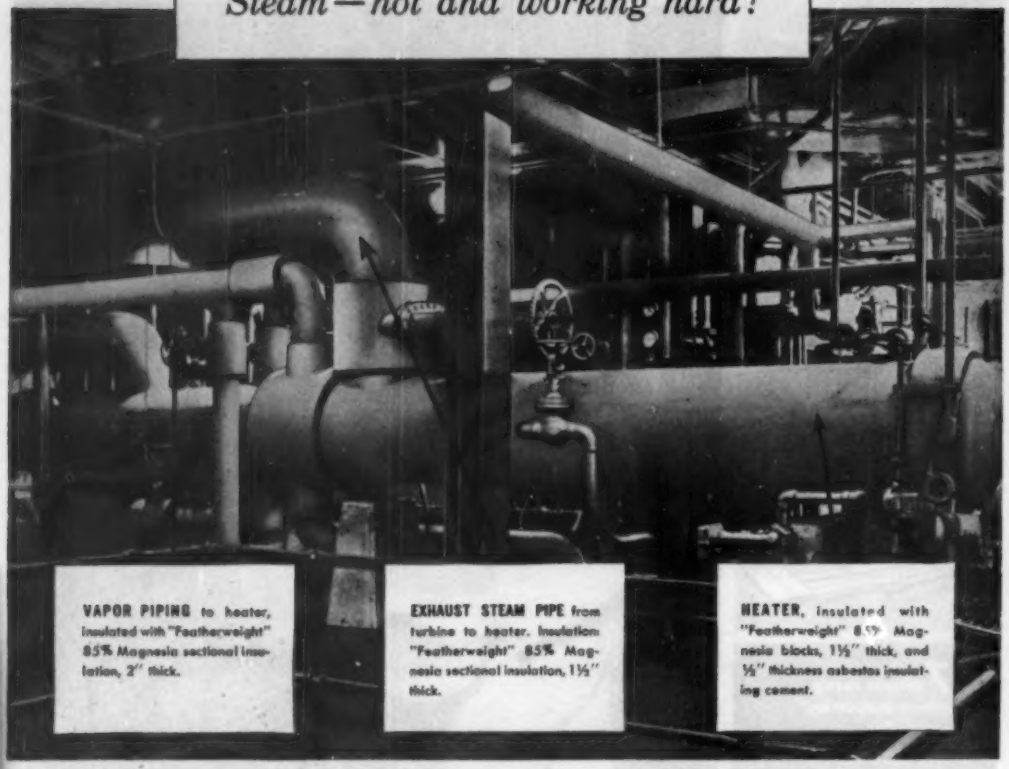
Write for copy of "Mobilized to Serve You"

UNARCO

UNION ASBESTOS & RUBBER COMPANY

332 SOUTH MICHIGAN AVENUE • CHICAGO 4, ILLINOIS DEPT. 1823

Steam—hot and working hard!


VAPOR PIPING to heater, insulated with "Featherweight" 85% Magnesia sectional insulation, 2" thick.
EXHAUST STEAM PIPE from turbine to heater. Insulation "Featherweight" 85% Magnesia sectional insulation, 1½" thick.
HEATER, insulated with "Featherweight" 85% Magnesia blocks, 1½" thick, and ½" thickness asbestos insulating cement.

These Keasbey & Mattison Insulations keep heat on the job—keep heating costs down!

Steam is expensive to produce . . . and far too valuable to waste. That's why "Featherweight"® 85% Magnesia was the insulation used in this large Southwestern utility plant.

"Featherweight" 85% Magnesia gives maximum protection against heat loss—keeps steam "on the job" wherever and whenever it's wanted!

This is but one of thousands of installations of "Featherweight" 85% Magnesia Insulation—on ships, in power plants, in the chemical process and food industries. With a background of more than 60 years' service, "Featherweight" is today one of the most widely used and favorably accepted insulations for temperatures up to 600° F. When used in combination with K&M Hy-Temp Insulation, "Featherweight" 85% Magnesia is efficient and practical for temperatures up to 1900° F.

Ask your distributor, who is also an experienced applicator, for complete information on "Featherweight" 85% Magnesia, or any insulations in the complete K&M line. Or, write us.

The newest development in thermal insulation: "KaytherM" High Temperature Blocks

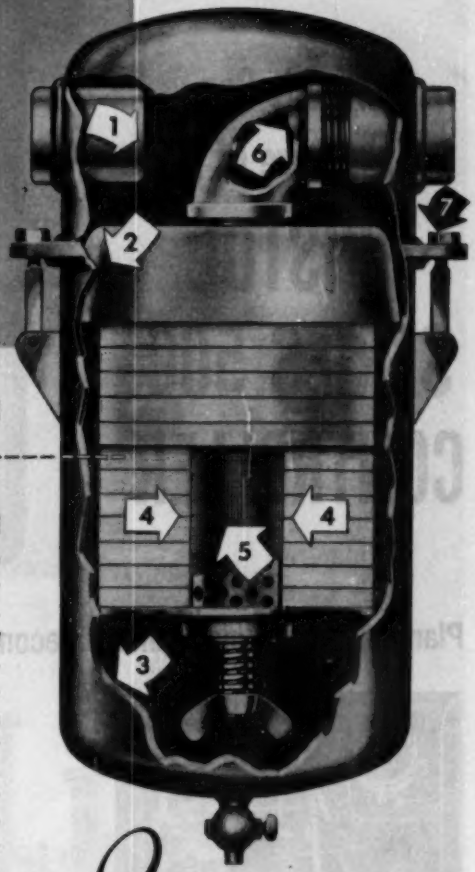
A product of years of research and development! "KaytherM" provides maximum efficiency up to 1500° F. It is molded to size . . . incombustible . . . insoluble in water . . . has exceptional strength and high dimensional stability . . . is light in weight . . . easy to handle . . . quickly applied. Available in flat blocks 6" x 36"; in thicknesses of 1", 1½", and 2".

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

Nature made Asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

K&M — Best in asbestos ®

Removes Last Traces of Oil and Moisture from COMPRESSED AIR LINES



THICK FELT DISCS PROVIDE SUPER FILTRATION

DOUBLE ACTION PRINCIPLE REMOVES MOISTURE AND DIRT TWO WAYS—Here's the greatest pipe line filter ever developed for removal of every trace of foreign matter, condensed oil and moisture. Compressed air is cleaned by both *mechanical separation* and *filtration/absorption.* Air entering filter inlet (1) strikes Deflector Cup (2) by which heavier droplets of water and dirt particles are directed to sides of Housing (3) and thence downward at high velocity to base where liquid and heavier particles are deposited. The *mechanically cleaned* air then passes at low velocity thru the Discs (4) which *filter* the air and *absorb* the last traces of oil and moisture. Clean, dry air passes out thru fine mesh Bronze Screen (5) and Outlet (6). Swing Bolts (7) on head for easy inspection are optional.

Originally designed for the protection of pneumatically operated control apparatus, these revolutionary filters are now used as a primary or final stage of filtration for an ever-increasing number of tools, devices and processes. Many highly successful installations are reported in which no other filter had proven satisfactory.

Request Bulletin B-1A, mentioning problem involved for specific engineering information. Please direct your inquiry to Dept. 47.

Staynew

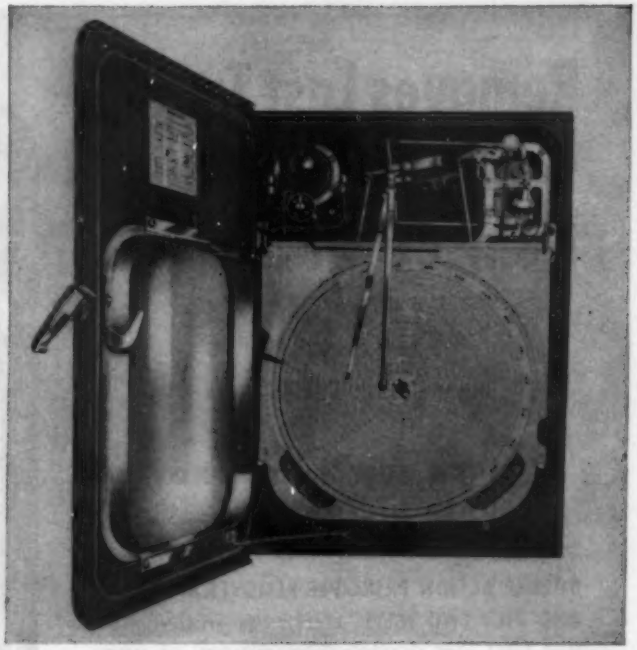
ABSORPTION FILTER

A complete range of sizes available, handling capacities from 5 to 100 CFM free air at 80 lbs. gauge pressure in standard pipe sizes from ¼" to 2". Model illustrated is AAPHS (swing-bolt head). Available also is Model AAPH, identical except for bolted-head construction.

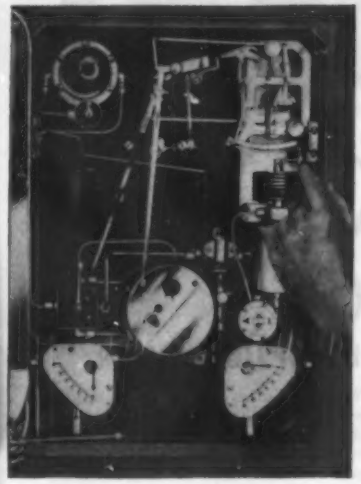
DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

DOLLINGER CORPORATION
11 CENTRE PK., ROCHESTER 3, N. Y.

Anybody Can Take Care of a BRISTOL SERIES 500 CONTROLLER



Plant operating men quickly become familiar with it... and like to use it



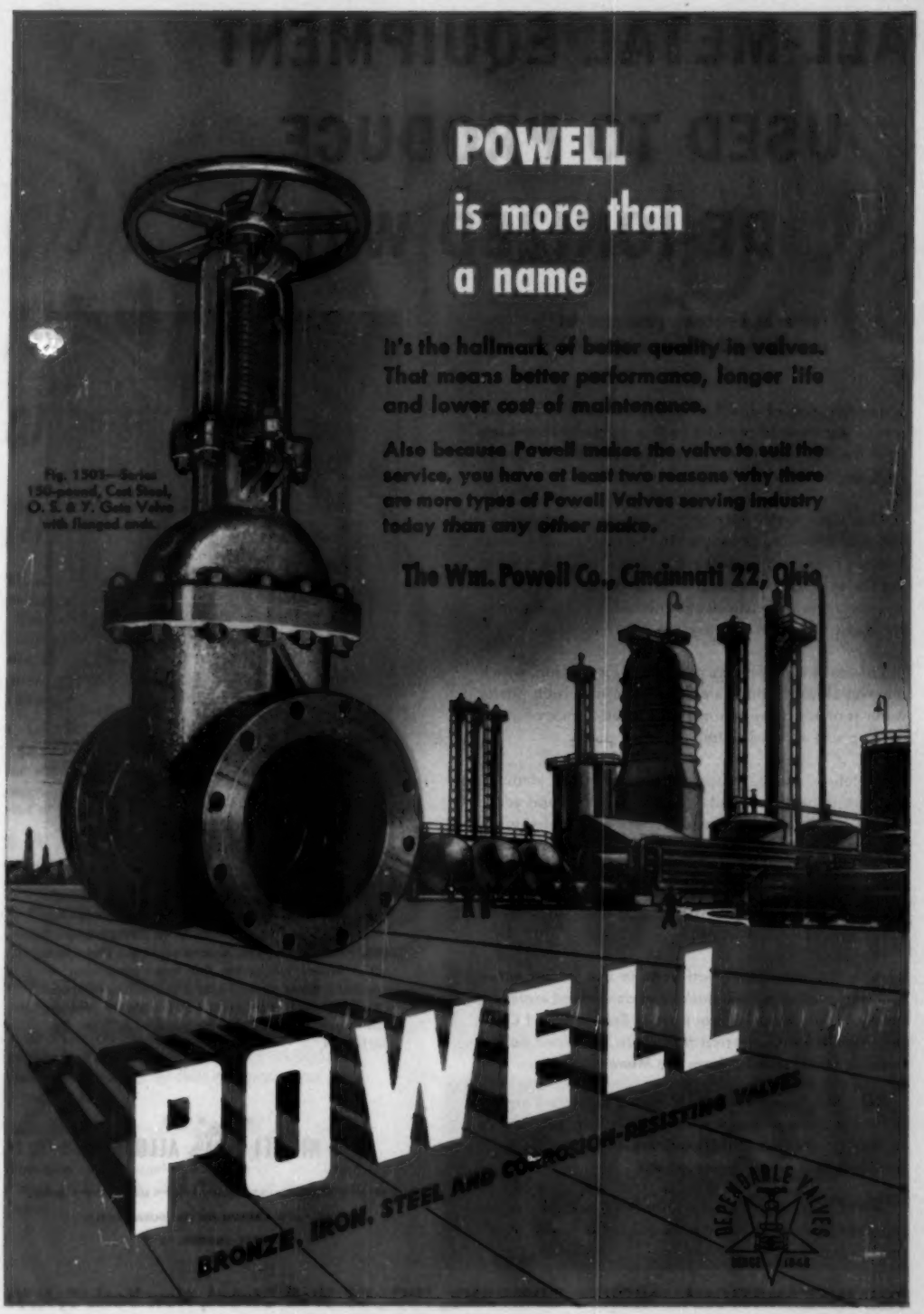
Only One Simple Adjustment

Write or call your local Bristol representative. And write for Bulletin A120. THE BRISTOL COMPANY, 111 Bristol Road, Waterbury 20, Conn.

THE DEPENDABLE GUIDEPOST OF INDUSTRY

BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS


POWELL
is more than
a name
It's the hallmark of better quality in valves. That means better performance, longer life and lower cost of maintenance.
Also because Powell makes the valve to suit the service, you have at least two reasons why there are more types of Powell Valves serving industry today than any other make.
The Wm. Powell Co., Cincinnati 22, Ohio
Fig. 1503—Series 150-pound, Cast Steel, O. S. & Y. Gate Valve with flanged ends.
POWELL
BRONZE, IRON, STEEL AND CORROSION-RESISTING VALVES
DEPENDABLE VALVES
SINCE 1842

ALL-METAL EQUIPMENT USED TO PRODUCE DE-IONIZED WATER

Mineral content reduced to less than 10 parts per million

The equivalent of distilled water, with a mineral content of less than 10 ppm—a 96% reduction—is flowing from the all-Monel de-ionizing system at the Swansboro Ice Company, Swansboro, North Carolina.

This equipment operates on the two-stage cation- and acid-removing principle. In the first stage, mineral salts are converted to their equivalent acids by exchanging the original cations for hydrogen ions. The second stage removes the entire acid molecule, leaving the effluent water free from the original dissolved solids.

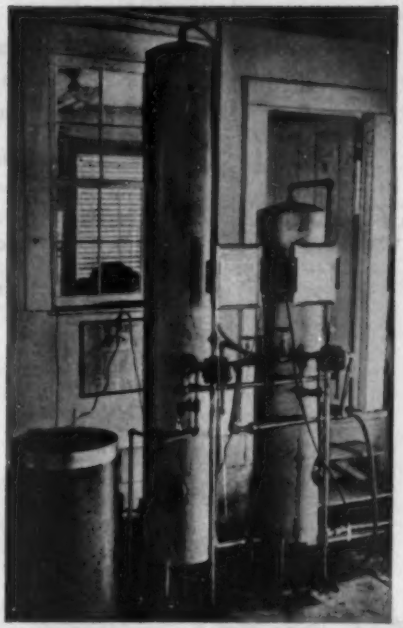
This is the only process, other than distillation, which removes all ions from water. But since such high purity water is obtained by de-ionization, even a trace of metal pick-up can seriously alter the final purity.

Therefore, metal equipment used must be virtually inert to the water carried through it. For several years, piping and fittings of Monel had been used in de-ionization, but it was not realized that entire units could be made of Monel. Then, with the Swansboro installation, it was proved that Monel's resistance to water was so high that metal pick-up from it would affect water purity negligibly, if at all.

After the equipment had been in use for an entire summer, producing 500 gallons of de-ionized water an hour, the fabricator, Hungerford & Terry, Inc., of Clayton, New Jersey, reported that there had been no detectable metal pick-up from the Monel surfaces.

Right now nickel and nickel alloy deliveries are extended because so much is being diverted for essential defense production. But if you have a high-purity problem, here is a practical suggestion:

Write INCO's Corrosion Engineering Service, outlining your problem. They will be glad to help you search out a solution.



This all-Monel de-ionization unit, in service at Swansboro Ice Company, Swansboro, N. C., reduces the mineral content of well water from 250 ppm to 10 ppm, with flow of 500 gallons an hour. The entire unit is Monel, except the side tanks containing regenerating materials—yet after a full summer's operation, there had been no detectable metal pick-up, according to the fabricator, Hungerford & Terry, Inc., Clayton, N. J.

EMBLEM OF SERVICE
NICKEL (INCO) ALLOYS

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL • "S"® MONEL
NICKEL • LOW CARBON NICKEL • DURANICKEL®
INCONEL® • INCONEL "X"®

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N.Y.

why ALCO AIRCOOLERS are specified for these Installations

There's no mystery about the preference for performance-proved ALCO Aircoolers. These efficient units are used everywhere by the oil industry to cool jacket-water, gas, engine lube oils, and to condense steam, vapors, etc. Users prefer them because they have five major advantages:

1. LOW COST—Goes way beyond first cost. ALCO standardized parts . . . broad heat-transfer experience . . . volume production . . . plus correctly engineered safety factors . . . insure *real* economies.

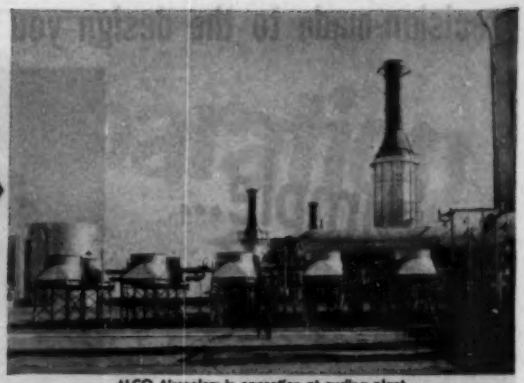
2. FLEXIBLE DESIGN—You can get either the radiator core or fintube type cooler from ALCO, powered by electricity, steam, gas or oil.

3. EFFICIENT PERFORMANCE—Induced draft design eliminates the chance of recycling hot air with a subsequent loss in heat transfer.

4. EASY MAINTENANCE—Fewer parts, easy accessibility and better wearing characteristics.

5. QUICK INSTALLATION—For fast field assembly, every part is marked and identified on assembly drawings so that no specialized labor is required.

Send now for free catalog, or call your nearest ALCO Sales Engineer at Beaumont, Chicago, Houston, Los Angeles, New York or Tulsa. Plants at Dunkirk, New York, and Beaumont, Texas.



ALCO Aircoolers in operation at cycling plant

ALCO Aircoolers on treating columns in a natural gas plant

ALCO Aircooler cooling jacket water for Diesel engines

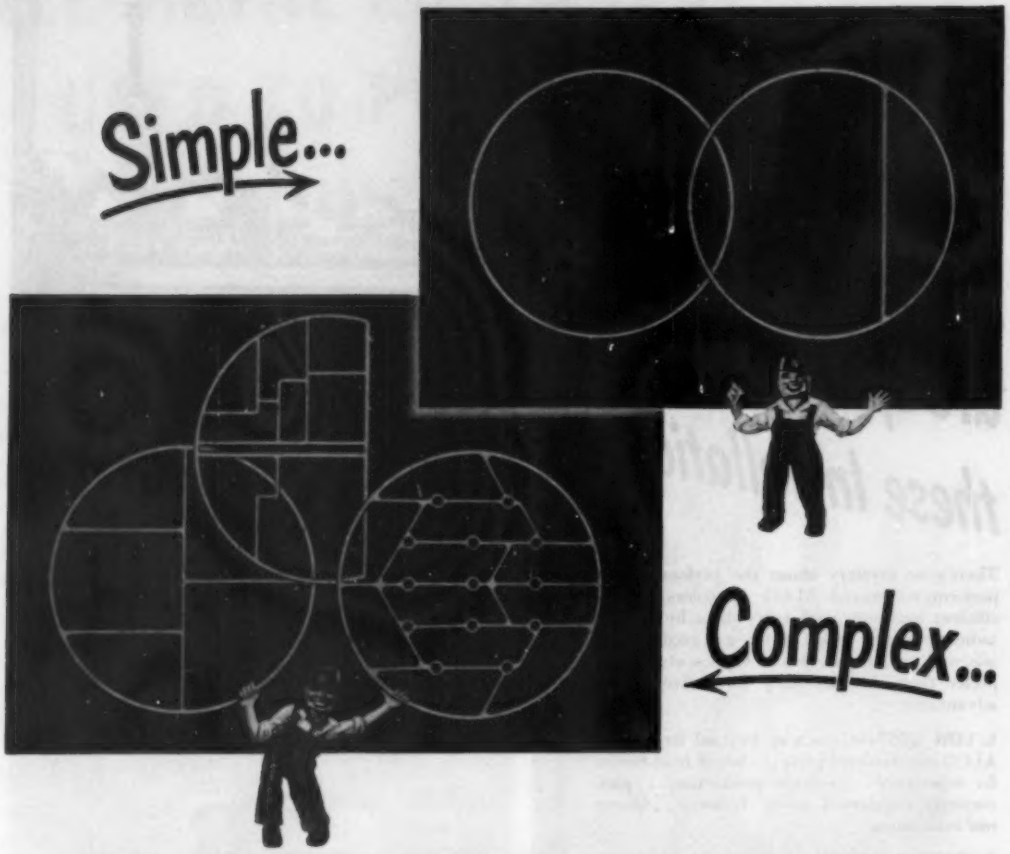
ALCO

ALCO Products Division
AMERICAN LOCOMOTIVE COMPANY

In step with tomorrow—**ALCO AIRCOOLERS, Heat Exchangers, Evaporators, Feedwater Heaters, Pressure Vessels, Pipe**

Precision-made to the design you need . . .

Simple...



Complex...

Goetze Heat Exchanger Gaskets stay on the job longer!

Whether your specifications call for a simple or complex design, you can depend on Johns-Manville Goetze heat exchanger gaskets to do the kind of sealing job that costs you less in the long run!

That's because they are carefully hand-tailored to assure the accuracy of fit so important in heat exchanger service. Every detail of construction reflects the craftsmanship that goes into the fabrication of these better gaskets. You'll find no wrinkles or cracks on the corners. Lap widths are ample, rib widths uniform.

More than 60 years of gasket-making experience is your further assurance that when you put a Goetze heat exchanger gasket on the job, you can count on it to *stay* on the job for a long time. For further details and a prompt estimate of cost, send us a blueprint or template. Just address Johns-Manville, Box 290, New York 16, New York.

JM

Johns-Manville Goetze GASKETS

THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE

Stop Tar Separation

in diesel and fuel oils . . . use

IONAD 17

Shell's fuel oil additive saves money four ways for refiners:

1. Ionad 17 eliminates filter screen clogging . . . the largest single cause of service troubles in domestic oil burner equipment. Burner parts are also kept free of tars and resins.

2. Ionad 17 makes fuel oil stocks more compatible.

3. Ionad 17 minimizes treatment of fuel oil stocks. In many cases the cost of adding Ionad 17 is *more than paid for* by savings in reduced fuel oil treatment alone.

4. Ionad 17 prevents the accumulation of sludge on tank bottoms. As a result, tanks require less frequent cleaning.

Ionad 17 is a stable concentrate that is readily soluble in fuel oil stocks. It prevents the agglomeration of the tars and resins that form in most fuel oils from the polymerization of olefins. Its advantages are now available to refiners of fuel oils—get complete information from the nearest Shell Chemical office.

THE SAME FUEL OIL!

WITH IONAD 17

WITHOUT IONAD 17

Both filter screens operated for 28 days with No. 2 fuel oil.

SHELL CHEMICAL CORPORATION

CHEMICAL PARTNER OF INDUSTRY AND AGRICULTURE

Eastern Division: 500 Fifth Avenue, New York 18
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Los Angeles • Houston • St. Louis • Chicago • Cleveland • Boston • Detroit • Newark

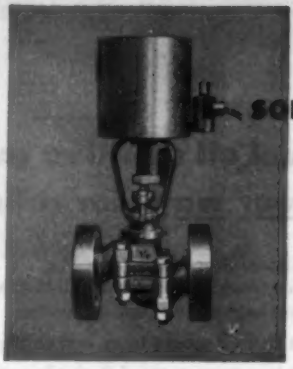
IONAD 17

Where Service Requirements demand the finest . . .

DOMOTOR

Precise control of hard-to-handle fluids. Powerful piston action combined with sensitivity and stability. Integral null type positioner eliminates external attachments.

There you'll find ANNIN VALVES



SOLENOID

Piston actuated by pressure regulated by 3- or 4-way solenoid pilot valve. Powerful valve action by remote control. Fast shockless action in all types of service.

Valve Buyers, as well as instrumentation engineers are specifying ANNIN Valves for critical fluid control applications where valve performance must be accurate and dependable. New revolutionary principles provide an additional range of possibilities in working out instrumentation schemes. Although new and different to many valve users, Annin single seated Valves have been thoroughly time-tested and field-proven in thousands of applications in all phases of industry.

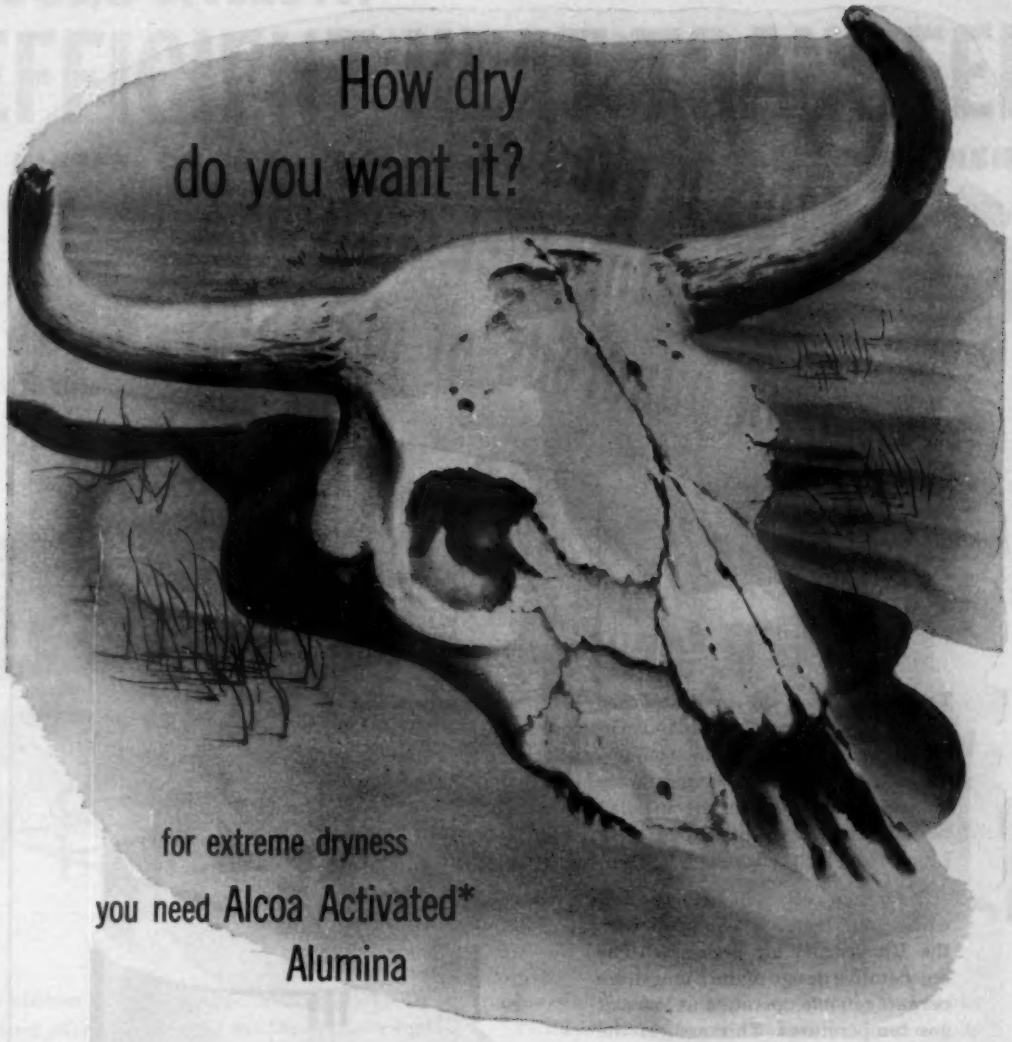
Superior performance at temperatures from −300° F to 1000° F and at pressures up to 3000 psi, plus lowered maintenance and inventory costs make ANNIN Valves first choice among valve users everywhere. It will pay you—in superior performance and lower operating costs—to investigate. Send today for Bulletin.

HANDWHEEL

Valuable companion in shut-off service to the Domotor under same operating ranges. Interchangeable characterized trims make it valuable for batch and non-continuous fluid processing control.

REMEMBER—*Teflon Chevron packing has been standard equipment on all Annin Valves for over two years.*

THE ANNIN COMPANY • 3500 UNION PACIFIC AVENUE • LOS ANGELES 23, CALIFORNIA



Every day more and more petroleum companies are discovering the efficiency and economy of ALCOA *Activated* Alumina for the dehydration of liquids, vapors and gases. They know that it's one of the most effective desiccants they can buy. Dew points as low as *minus 100° F.*—and even lower—can be obtained, and ALCOA *Activated* Alumina can be used for an almost indefinite number of drying cycles.

ALCOA *Activated* Alumina has high resistance to crushing, shock and abrasion . . . will not soften, swell or disintegrate even when immersed in water . . . is non-toxic . . . non-corrosive . . . high in purity . . . practically iron-free.

ALCOA *Activated* Alumina is used to adsorb certain gases and vapors from gaseous mixtures, and serves as a catalyst and catalyst carrier.

What do you dry? How dry do you want it? Whatever your answer, it will pay you to investigate ALCOA *Activated* Alumina. We will gladly send you complete information. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 617M Gulf Building, Pittsburgh 19, Pennsylvania.

**Reg. T.M., Aluminum Co. of America*

FREE—A large color print of this illustration on heavy stock, without advertising matter, suitable for framing. Write us.

Alcoa Chemicals

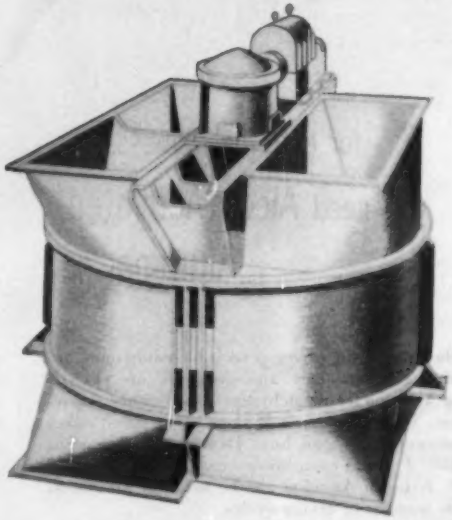
ALCOA

ALUMINAS and FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE • GALLIUM

...heater ...fuel costs ...ds of plants!

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.



The Ljungstrom air preheater has proved its value in industrial and utility plants throughout the country. That is why every year a constantly increasing percentage of the installed boiler capacity is equipped with Ljungstrom air preheaters.

Your fuel costs will be lower too, when your boiler is equipped with the Ljungstrom air preheater. The regenerative design of the Ljungstrom permits reliable operation at low exit gas temperatures. This assures the greatest possible heat recovery . . . reduces the amount of fuel required.

If you are planning a new installation, or expanding your present one, our engineers will welcome the opportunity to show you how the Ljungstrom air preheater can raise the overall efficiency of *your* plant.

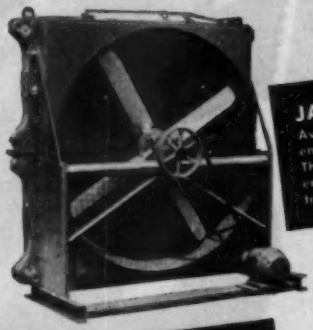
THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

YOUNG OFFERS . . .

EFFICIENT HEAT TRANSFER

IN WATER, OIL, GAS COOLING-STEAM AND VAPOR CONDENSING

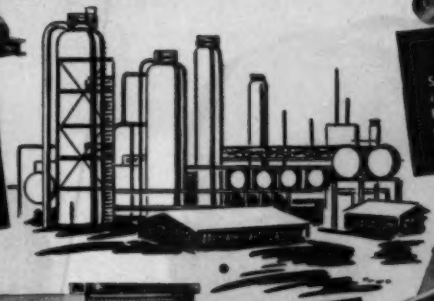


JACKET WATER COOLERS

Available in a wide range of sizes for engine jacket water or lube oil cooling. These units are sturdy, compact, and engineered to provide maximum heat transfer with low hp requirement.

"HC" COOLERS

Multiple unit installations provide economical handling of water, oil or gas cooling and steam and vapor condensing in any combination. Easily installed in the field.

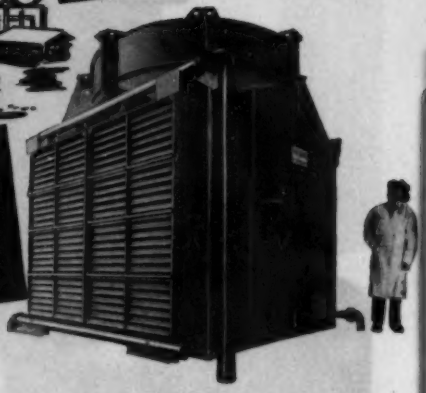


HEAT EXCHANGERS

Space-saving units available from stock in fixed or removable tube bundle types. For jacket water or lube oil cooling in stationary or marine (fresh and salt water) applications.

"VAD" COOLING AND CONDENSING UNITS

Vertical air discharge units for extra large capacity cooling of water, oil and gas and condensing of steam and vapor in any combination. Low-level mounting means ease and economy in maintenance.



In addition to the field-tested products shown above, Young offers: gas, gasoline and Diesel engine cooling radiators; atmospheric and evaporative coolers and condensers; supercharger intercoolers, and similar products for the Petroleum Industry. Young supplements the design engineering of its equipment with application ingenuity thereby increasing the practicability of all Young products. For example, the popular "Vertiflow" Unit Heater, has been used successfully as an economical condenser. It can also cut heating costs by using the waste heat from engine jacket water for space heating. Young *engineered* applications cost no more. Contact your nearest Young Representative for further details.

YOUNG

Heat Transfer Products for Automotive and Industrial Applications.

Heating, Cooling, Air Conditioning Products for Home and Industry.

YOUNG RADIATOR COMPANY

Dept. 251-M • RACINE, WISCONSIN

Factories at Racine, Wisconsin and Mattoon, Illinois

OIL FIELD DISTRIBUTORS:

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LOS ANGELES: Flournoy & Everett, Inc., 5043 Santa Fe Ave.

MUSKEGON: Harold J. Young, 206 Montgomery Bldg.

Other Representatives in Principal Cities

COUPON BRINGS DETAILS ON YOUNG PRODUCTS

YOUNG RADIATOR COMPANY
Department 251-M
Racine, Wisconsin

Please send information on the Young Products checked below; also name and address of your nearest representative.

- ☐ Heat Exchangers
- ☐ Jacket Water Cooling Radiators
- ☐ "HC" Cooling and Condensing Units
- ☐ "VAD" Cooling and Condensing Units

NAME_____

COMPANY_____

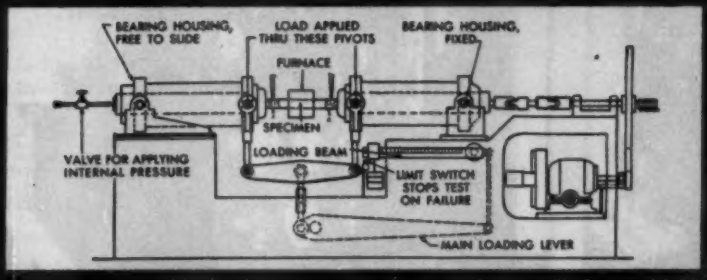
ADDRESS_____

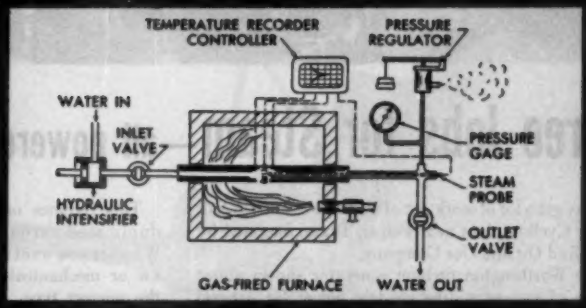
CITY_____ ZONE____ STATE_____

18,000 RESEARCH MAN-HOURS

toward better welding of dissimilar metals

BABCOCK & WILCOX





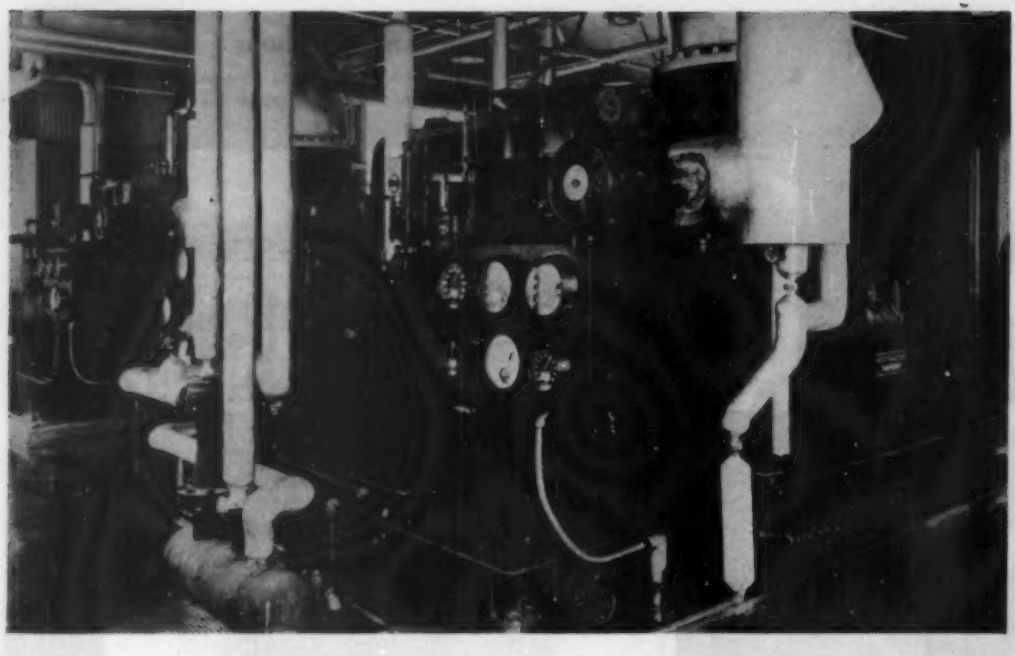
STEEL assumes many forms to meet the increasingly severe conditions of modern processing temperatures, pressures, and stepped-up cycles of operation. The use of several different steel analyses together may be necessary to obtain optimum dependability, service life, and economy in vessels and heat-transfer units.

THESE STEELS, individually, and under conditions each must meet—are stable, tough, flexible, and strong. However, when welded together, they tend to become intractable . . . creep, flow, stretch, warp, harden, crack, and otherwise change at the welded joints to a dangerous and costly degree. B&W is constantly seeking improved methods of welding—to curb these capricious traits of modern alloys.

FOR EXAMPLE: B&W is continuing a four-year-old project, involving over 18,000 research man-hours, on joining widely dissimilar alloys in tubular form. Findings have already produced new methods of control and new welding techniques that are measurably superior to any used before.

THIS SORT OF CREATIVE RESEARCH approach to problems of fabrication is characteristic of the many plus values that distinguish all B&W-built process equipment.

B-408T



Three Jobs for Steam—all powered by Worthington

They get a lot of work out of steam at Burnell-North Pettus Cycling plant near Pettus, Texas, operated by Stanolind Oil and Gas Company.

The Worthington turbine generator shown above is one of two providing electric power for general plant service. The steam turbines are 1,500 kw units, operating at 600 lb. gauge, 725 Ftt, and exhausting to 27 in. vacuum. The generators operate at three phase, 60 cycles, 70% power factor and are equipped with top-mounted air coolers.

There are also *nine* Worthington mechanical-drive turbines at this plant. Seven of these drive centrifugal pumps, and two drive induced-draft fans.

So — three jobs in all: electricity, pumps, fans.

This reliance on Worthington steam turbines is duplicated throughout the petroleum industry. Whether you want turbine-generator sets up to 10,000 kw or mechanical-drive turbines, Worthington has the correct type and size, with the petroleum industry's stamp of approval. A broad line of power plant equipment, giving you *unit responsibility*, and our unmatched experience in power plant applications are further reasons for doing business with Worthington.

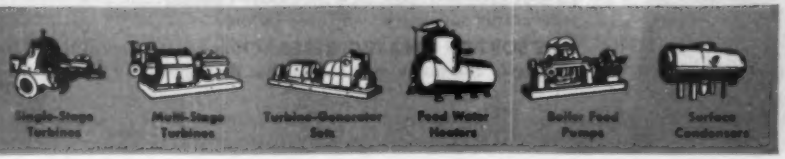
Get the *savings* that steam offers—get *more work* out of steam. *There's more worth in Worthington.* For bulletins, write Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N.Y.

WORTHINGTON

STEAM TURBINES

T.1.2

A GREAT TEAM IN STEAM



Easy does it—FAST!!

Rolling-in ELECTRUNITE Stainless Steel Pressure Tubes at Struthers Wells Corporation, Warren, Pa.

● Always uniform in size . . . always uniformly ductile . . . ELECTRUNITE Stainless Steel Heat Exchanger and Condenser Tubes always roll in smoothly and easily. For complete information about these modern pressure tubes, write to:

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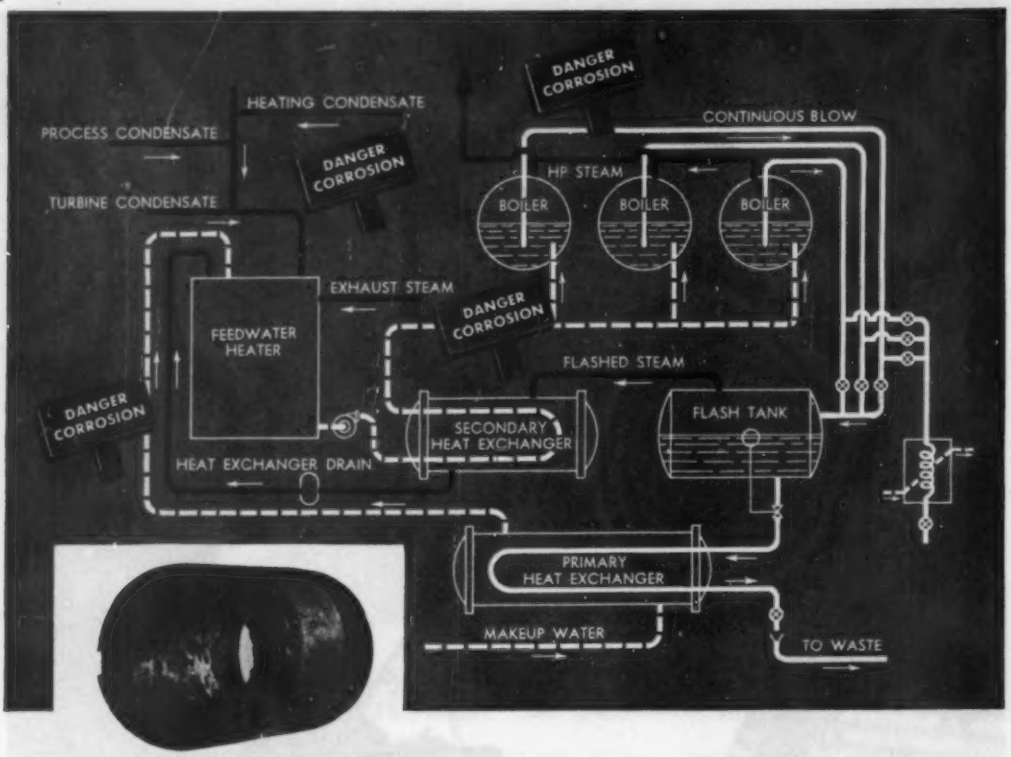

AVOID These Danger Signs with BIRD-ARCHER Amine Treatment

CORRODED condensate return lines lead to expensive pipe replacement and maintenance. As an added annoyance, the solid products of corrosion often plug return lines and fill traps. You can steer clear of these troubles by using the *effective, economical* Bird-Archer Amine Treatment.

HERE'S THE WAY THIS B-A TREATMENT WORKS

Amines are fed into the boiler or into the steam and condensate systems. The amines raise the pH value of the condensate and also tend to inhibit equipment-destroying corrosion through surface protection of the metal itself.

HERE'S HOW THIS B-A TREATMENT SAVES MONEY

Raising the pH value of the condensate severely decreases maintenance costs by eliminating corrosion. These savings may more than offset the amount of treatment required to provide protection for your equipment.

NEW BULLETIN gives full details on the Bird-Archer Amine Treatment. . . . contains case histories that prove its successful application in many plants. *Write for your copy today.*

BA-184

WHAT AMINES ARE

Amines are members of a class of chemical compounds in which one or more hydrogen atoms of the ammonia molecule are substituted by an organic group. Some of the simpler types are soluble and volatilize from boiler waters. The alkalinity of the amines is an inherent property and does not result from decomposition. *No free ammonia is released.* In the concentrations necessary for protection of condensate systems, amines are harmless to non-ferrous metals, non-toxic and are completely stable at temperatures approximating 675F.

BIRD·ARCHER
WATER TREATMENT

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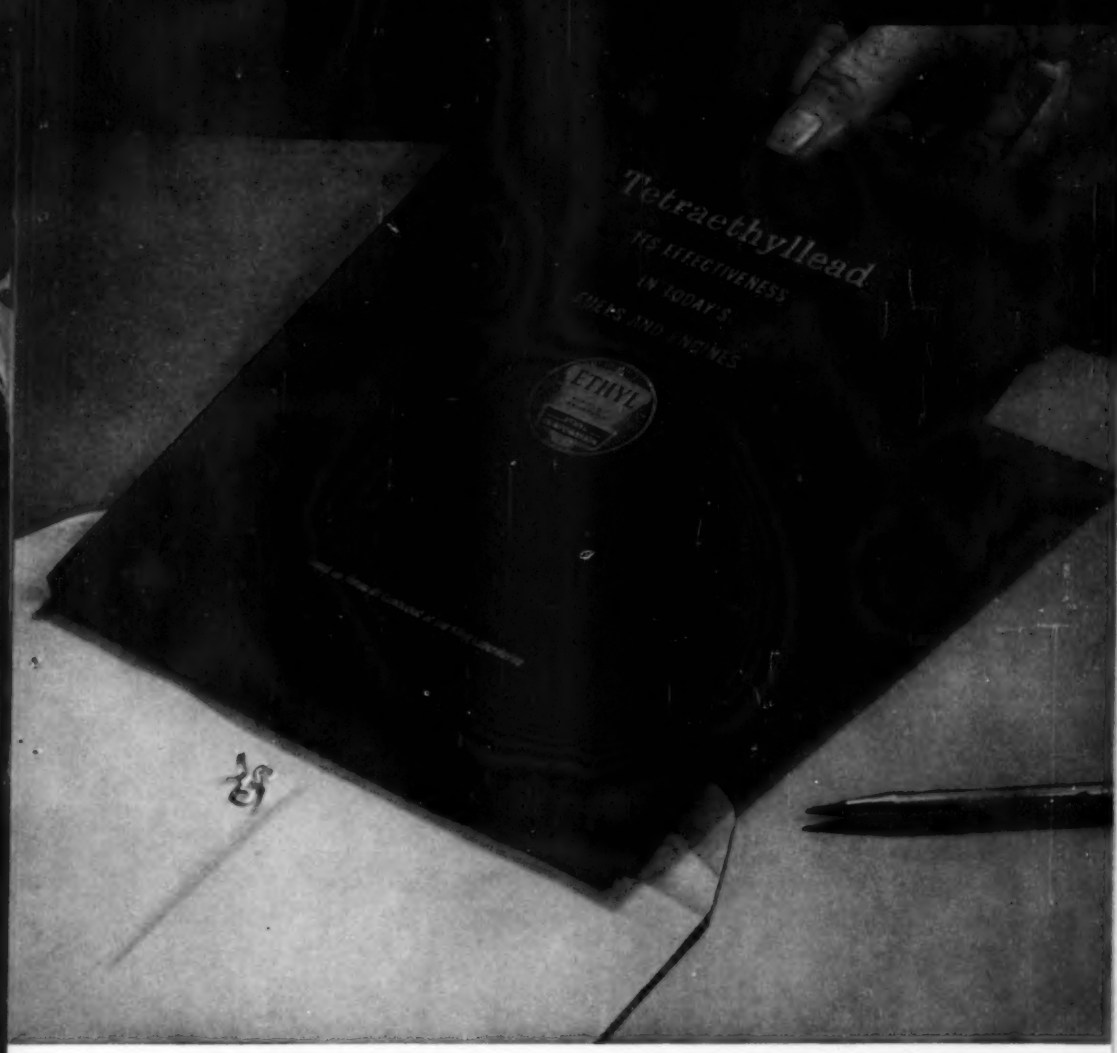
IN MEXICO: Calderas y Accesorios, S. A., Amsterdam 291, Mexico, D. F.



It took twenty-eight years to write this book

Twenty-eight years ago the first antiknock compound containing tetraethyllead was marketed. At that time, the need for some means of suppressing knock was obvious.

But it is extremely unlikely that automotive and petroleum engineers wrestling with the problems of 1923 would have anticipated that the antiknock compound which solved so many of their difficulties then would prove to be even more valuable a quarter of a century later.

How could they possibly have known that tetraethyllead would become more effective as advances were made in the refining of gasoline? How could anyone have foreseen that leaded fuels of high octane number would show greater "sensitivity" than clear fuels of the same number—thus making tetraethyllead even more valuable as engine designers took advantage of this

(continued on next page)

It took twenty-eight years to write this book

(*continued from preceding page*)

increased "sensitivity"?

How could even the most progressive thinkers have anticipated a time when progress in the refining of gasolines and in the design of engines would be such that the third cc of tetraethyllead would allow as much increase in compression ratio as the first cc did in 1923? And there was certainly no hint of the part tetraethyllead might someday play as a suppressor of auto-ignition.

Only after years of observing and accurately measuring the effectiveness of tetraethyllead under a wide variety of conditions could facts such as these—and the reasons behind them—be clarified. Actually, within the covers of this book, there have been compressed the essential findings of twenty-eight years of intensive research.

We feel that the information contained in "Tetraethyllead—Its Effectiveness in Today's Fuels and Engines" will be of interest and value to you. If, by some chance, you have not received a copy, we will be pleased to send you one.

ETHYL CORPORATION
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Ethyl service is backed by 28 years of antiknock experience

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Pritchard Designs for Versatility and Accessibility

Our Single Responsibility Contract includes:

- Design
- Processing
- Engineering
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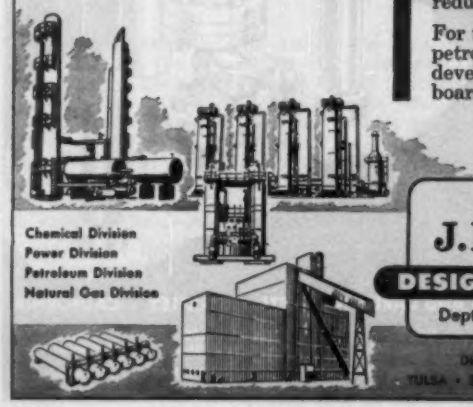
- Field Construction
- Guarantees
- Operating Tests
- "Turnkey" Basis

This unit is typical of Pritchard's forward looking ingenuity in Design, Engineering and Construction. Designed to the customer's requirements for replacement of an existing crude unit and for processing six different types of crude oil at a nominal capacity of 22,500 bbls. day, this unit simultaneously produces eight different distillate fractions ranging from light gasoline to cylinder stock!

At the same time particular care was taken to design the unit for maximum accessibility to the heat exchanger equipment, thus facilitating handling and reducing "shut down" time and maintenance costs.

For the most modern advancements in petroleum processing, let Pritchard engineers develop your next project from drawing board to "on stream."



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GAUGE SERVICING

Expedited!

HERE'S the ideal team for greater efficiency in gauging pressure storage tanks. It's the Shand & Jurs High Pressure Automatic Tank Gauge and High Pressure Tape Block Valve. This combination expedites gauge servicing and provides repeated gauging accuracy. On batteries of pressure storage tanks interconnected by catwalks, this team provides eye level tape reading without use of elbows and pulleys and with a minimum of piping.

The S&J High Pressure Automatic Tank Gauge, Fig. ST-400R, is designed for working pressures up to 150 pounds. A heavier model, designated Model 400PR, is suitable for working pressures up to 300 pounds. The large reading window of the gauge is retained from the inside utilizing tank pressure for tightness. The window is protected by a steel door which must be lifted for each reading, then falls back covering the glass safeguarding the tank from the remote possibility of window breakage.

The S&J High Pressure Tape Block Valve, Fig. ST-5265, is installed on the tank top ahead of the pipe carrying the tape to the gauge head. It permits isolation of the gauge head from tank pressure and vapors in the event maintenance, inspection or replacement of parts is necessary. This "sealing off" operation can be easily accomplished in a matter of seconds. The tape block valve is made for both 150 and 300 pound working pressures.

S&J

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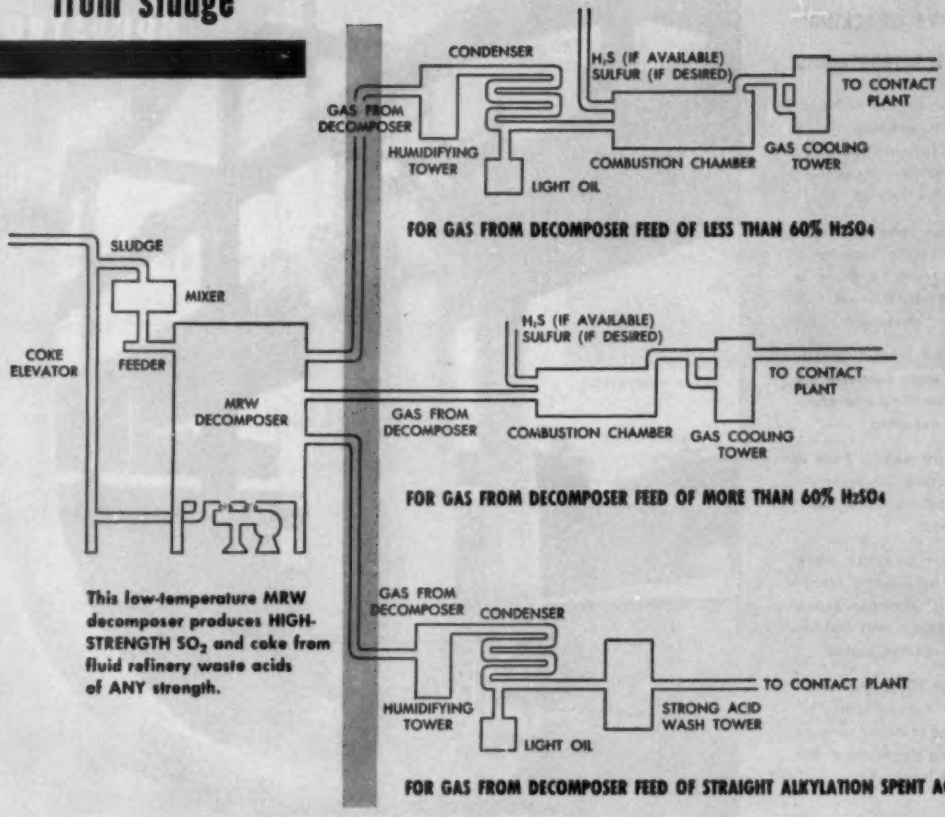
How to make white sulfuric acid from sludge



Clean, white sulfuric acid, of any desired strength, can be made from your refinery sludge or H_2S—or both together—with a Monsanto-Ross-Wilde sludge recovery unit. This unit may operate with your present contact sulfuric acid plant or, if you have no plant, Monsanto will design your sludge recovery and sulfuric acid units as a single project.

In addition to sulfuric acid, these units recover oil from some type of sludge that can be refined into salable products.

Community relations are improved by eliminating stream and atmospheric pollution. Urgently needed tank cars, now used to carry away sludge and to return reclaimed acid, will be available for other purposes once your Monsanto-Ross-Wilde sludge recovery unit is in operation.

Because of present sulfur shortage and the growing use of sulfuric acid, a Monsanto-Ross-Wilde sludge recovery unit should be a sound investment for the present and future.

At your request, and without obligating you, a Monsanto representative will visit your plant and estimate the cost of a Monsanto-Ross-Wilde installation. He will show you how much acid you can produce . . . how much you can save on waste disposal costs. Write, wire or telephone MONSANTO CHEMICAL COMPANY, Engineering Sales Department, 1776-L South Second Street, St. Louis 4, Missouri.

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CHEMICALS — PLASTICS

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YOU

CAN MAKE YOUR REFINERY OPERATIONS LESS "HEAVY WRACKING" WITH NORDSTROMS

You can repack a Nordstrom Hypersteel Valve under full load and in any position without shutting down the line.

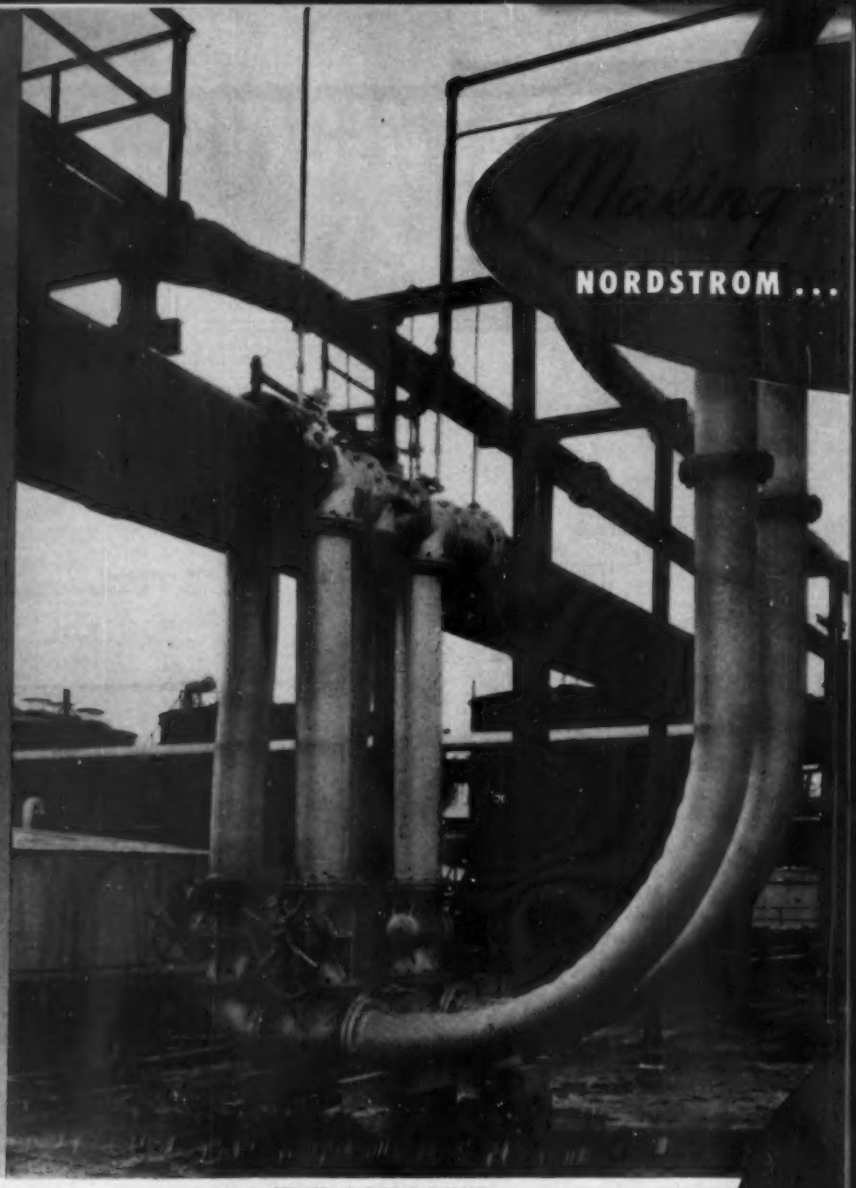
You can lubricate Nordstroms more easily because a Nordstrom is only at quarter turn from full open to full closed.

You can install Nordstroms more economically because they are especially designed.

You can easily turn a Nordstrom because its plug rotates on a lubricated seat.

You can operate more safely because a Nordstrom is lubricant-sealed around each port and the plug is always seated.

You can keep Nordstrom Valves automatically lubricated in many services by using Hypermatic, the miracle lubricant.



REFINERY GAS TO GAS PLANT

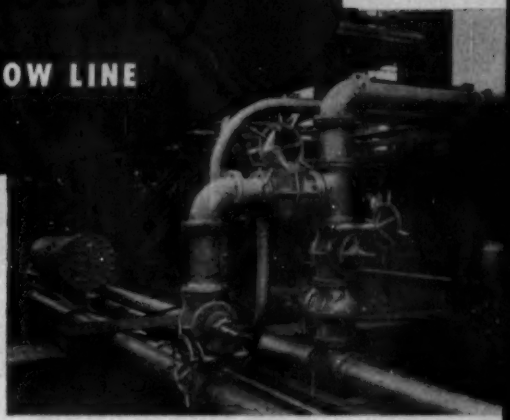
Nordstrom Valves

★ **PRESSURIZED LUBRICANT SURROUNDS AND SEALS EACH PORT**

★ **SIMPLE ROTARY ACTION OPENS AND CLOSES VALVE IN 90°**

AUTOMATICALLY LUBRICATED WITH — *THE MIRACLE LUBRICANT*

. . . PAVES THE WAY ALL ALONG THE FLOW LINE

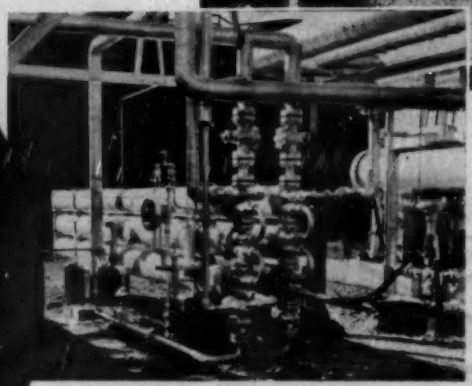


NORDSTROM VALVES ON RESIDUE SWITCH AND DISCHARGE LINES

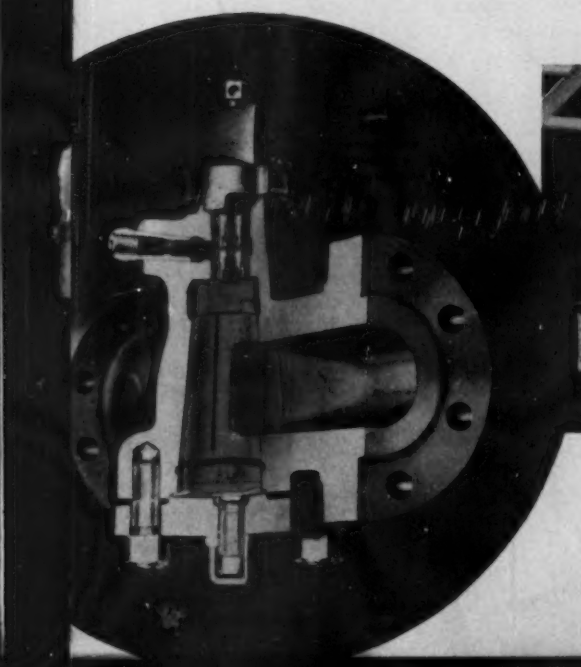
So much depends on valves!

Refinery engineers are setting ever-higher standards of performance. They have come to know that these standards, regardless of how stringent, can be met by Nordstrom valves. In fact many refinery services demand Nordstroms because the basic principle of design insures dependable operation under conditions far beyond the limits of conventional valves.

NORDSTROM VALVES ON DE-ETHANIZER AND REFLUX PUMPS



NORDSTROM VALVES ON RAW PRODUCTS EXCHANGERS



KEEP UPKEEP DOWN with Nordstroms

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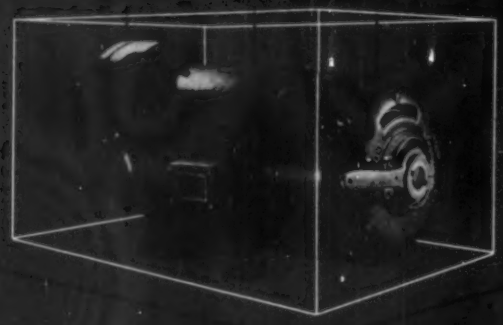
Atlanta, Boston, Chicago, Columbus, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, Tulsa . . . and leading Supply Houses • Export: Rockwell Manufacturing Co., International Division, 7701 Empire State Bldg., New York 1, N.Y.



Don't put up with make-shift assemblies when it is so easy to get the RIGHT horsepower, the RIGHT shaft speed, the RIGHT construction features, the RIGHT mounting . . . all combined into one compact, easy to use power package.

All in one package

Master Gearmotors, available in millions on millions of combinations of types and ratings, permit you to use a power drive on each job that's just right . . . a power drive that will add greatly to the compactness, appearance, and economy of each of your applications.

Use Master Gearmotors to increase the salability of your motor-driven products . . . improve the economy and productivity of your plant equipment. They're the horsesense way to use horsepower.

THE MASTER ELECTRIC COMPANY
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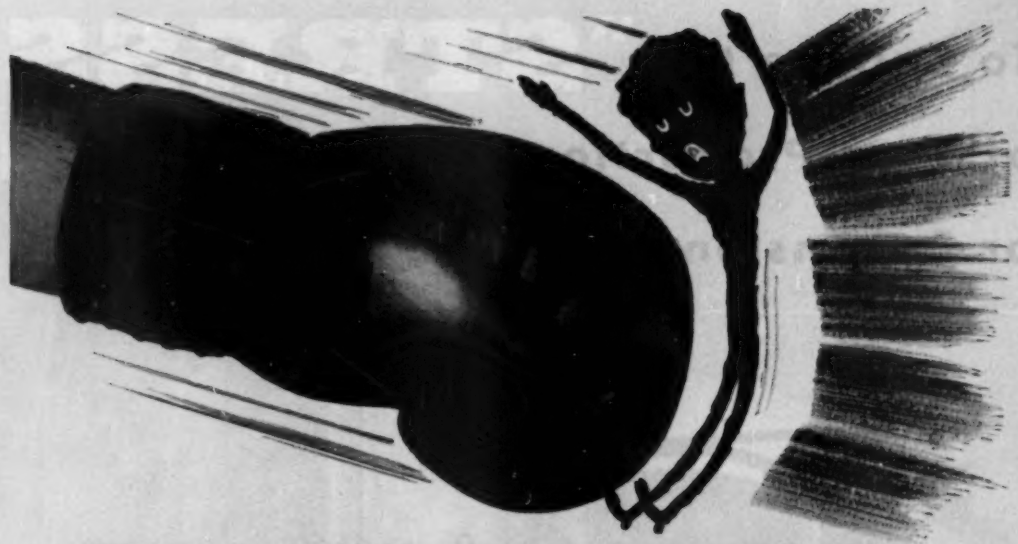
MASTER GEARMOTORS



IT'S A ONE-PUNCH FIGHT...

. . . when a Lagonda 1100 Series tube cleaner tackles the toughest coke that ever fouled a still tube. The Lagonda cutter head wades into the battle slugging at every step, backed up by the irresistible wallop-power of the precision-built 1100 Series motor, with its ball thrust bearings at each end plus its positive lubrication system—features that combine to let the power flow right through to the cutter head, where it will do the most good.

The whole thing is a combination—a super-powerful motor, armed with a super-tough cutter-head that has all the necessary stamina to take the motor's power and turn it into smashed coke. With a combination like this you cut down-time to the bone. Try it. A Lagonda field engineer will help, if you like.

BULLETIN Y-29 gives some pretty convincing facts how to make any coke "say uncle". Mailed on request.

ELLIOTT COMPANY
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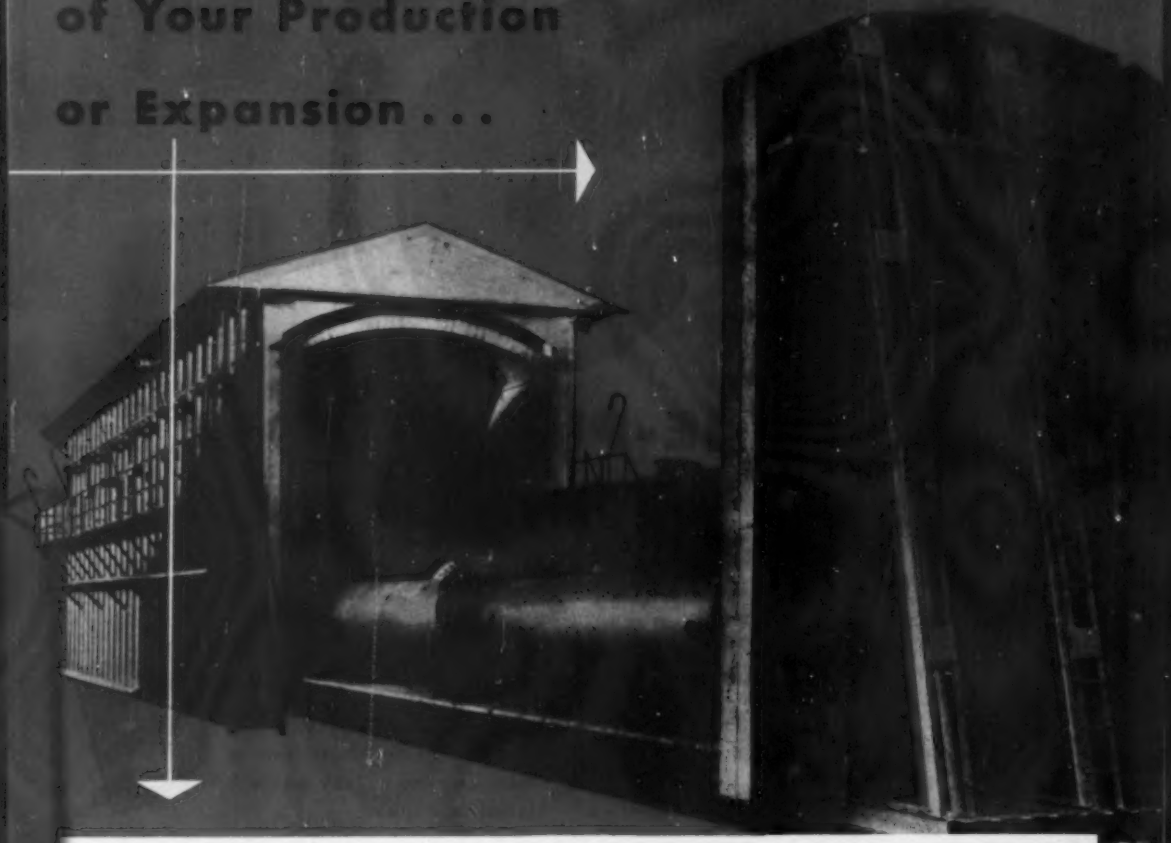
Y-304

To Relieve the "STRESS" of Your Production or Expansion . . .



Black, Sivalls & Bryson has one of the largest stress-relieving ovens in the world, strategically located at Oklahoma City. If you are planning expanded facilities, increased or diversified production, new special equipment, consider what the capacity, speed and efficiency of this huge metal-treating monster can mean to you — in savings of investment, production costs and time. Yet this oven is only *one* of the many BS&B facilities available for the fabrication of your large weldments, pressure vessels, or other metal products required by your plant.

With a background of 58 years experience in designing, engineering and manufacturing equipment for the Oil, Gas, Chemical and other processing industries, BS&B has the engineering and laboratory staffs to assist you with design and metallurgic problems; plus the precision manufacturing facilities and quality control methods for efficient, economical fabrication.

If your requirements can be served in the Midwest, why not let us see if BS&B's varied facilities can assist you? Your inquiry is treated in strict confidence.

BS&B

Write Dept. 90-F.

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prevents wear on seats of

CHAPMAN

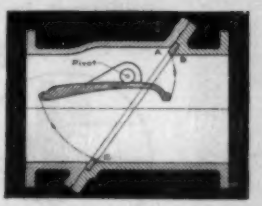
Tilting-Disc CHECK VALVES

Here's the check valve with the balanced disc which is cushioned to a quick and quiet closure by the flow of gases or fluids as you can see in the cross-section at the right.

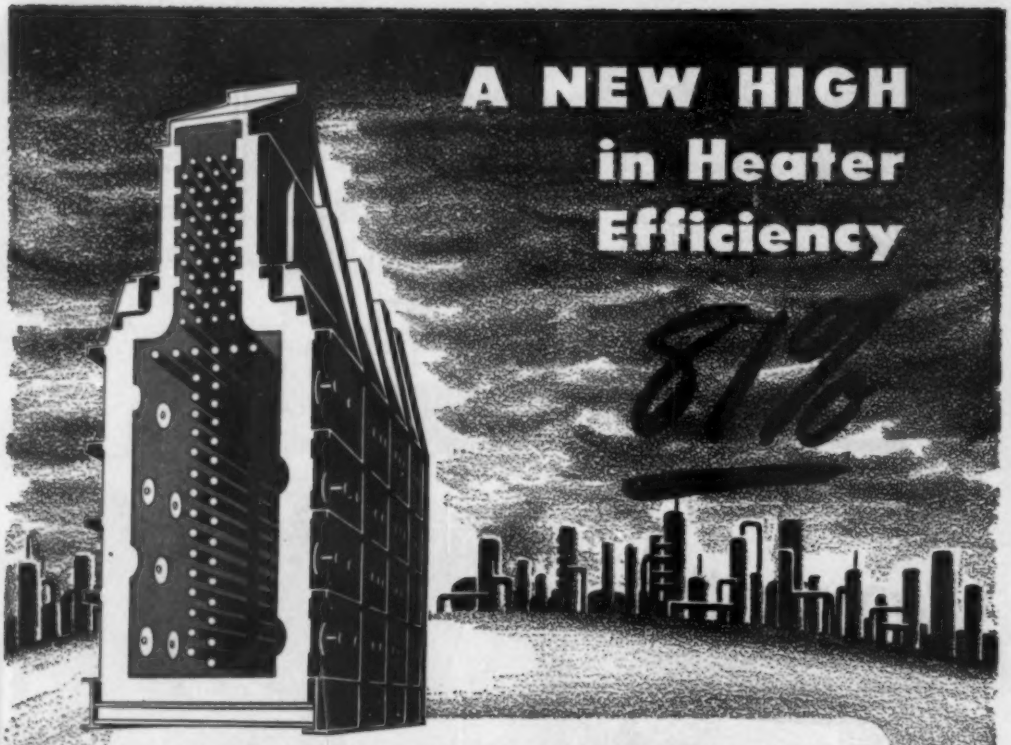
This smooth action prevents undue wear on seats, hinge pins and bearings . . . *and on your maintenance budget!* For there's no loosening of lines by vibration, no opened joints or ruptured pipes.

What's more, head losses are 65% to 80% less than conventional swing-type checks. Available in iron or steel in all standard pipe sizes. Get the complete story on this and other cost-cutting features of Chapman Tilting-Disc Check Valves, in the latest bulletin, No. 30. Send for your copy now.

THE CHAPMAN VALVE MFG. CO.
INDIAN ORCHARD, MASSACHUSETTS



Cross-section of the Chapman Tilting-Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.



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SELAS Gradiation® HEATER

Selas Gradiation brings a new, high efficiency to petroleum processing, new economies and increased daily production of high octane gasoline and distillates. Product quality has been improved at *lower* costs.

Selas Gradiation is based upon a new technique of applying gas as an industrial fuel. Combines high temperatures, fast, automatic operation and precise control of radiant heat. Provides outstanding fuel economy. Gives flexibility in shaping the time-temperature heat curve to meet exact requirements. Selas Gradiation assures new profitable possibilities for large and small refinery operations.

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Has true radiant wall principle, radiating heat at controlled rates to tube surfaces . . . Requires less tube surface. Counter current heat flow is efficient. Pressure drop is low. Coil residence time is short. Rate of heating curve can be controlled and fuel efficiency is high.

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You'll want this valuable, well-illustrated 16-page book, that tells how to increase your heat processing operations . . . improve quality, from crude distillation to vapor superheating. Write today for free copy of Selas Gradiation Heater.

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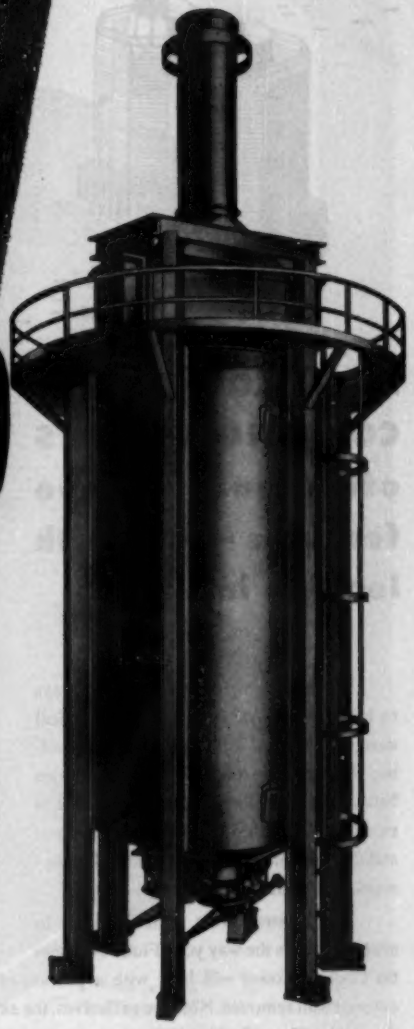
★ **For Direct Heating of Liquids and Vapors**

★ **Indirect Heating Systems Using Circulating Medium**

Struthers Wells

for the Process Industries



A complete line of direct fired heaters is available in standard sizes from 100,000 to 25,000,000 BTU per hour. These units are in wide use in services such as heating gasoline, oils or asphalts, superheating steam or gas, and for indirect heating systems. The heaters are shipped shop assembled except for the largest sizes.

Struthers Wells indirect heating systems, utilizing either a vapor or liquid heat transfer medium, such as Dowtherm, are giving economical and trouble free operation at temperatures to 750° F., or above this.

Equipment is ordinarily supplied with instruments and safety controls to give a complete installation. Large installations in service for many years testify to the correct design and quality of this equipment.

If your process requires temperatures above those of existing steam supply, if steam is not readily available, or if the process can be improved by higher temperatures, this economical and simple equipment will be of interest. We can also supply smaller equipment, electrically heated, as package units.

Write on your letterhead for our new Bulletin B-45, describing a complete line of equipment for high temperature process heating.

Struthers Wells

STRUTHERS WELLS CORPORATION
Warren, Pa.
PLANTS AT WARREN, PA. • TITUSVILLE, PA.
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FLUOR COUNTERFLO COOLING TOWERS offer many unique features — all worth looking into!

When selecting cooling towers, it pays to look into the structural and mechanical design features of a Fluor Counterflo Cooling Tower. It is here that the difference between one cooling tower and another is evident—where the difference in structural stability, maintenance of mechanical equipment, and quality appearance lies.

The illustration at right—accurate in every detail—is the way your Fluor Counterflo Cooling Tower will look with a portion of the exterior wall removed. Note the exclusives, the extras, that make Fluor Cooling Towers a wise buy. When *dependable* performance, *low* maintenance, and *quality* appearance is essential or desirable in your plant or process operations, look into a Fluor Counterflo Cooling Tower.

Fluor Counterflo Induced-Draft Cooling Towers incorporate many important design features which cut the cost of maintenance and improve the appearance of cooling equipment installations.

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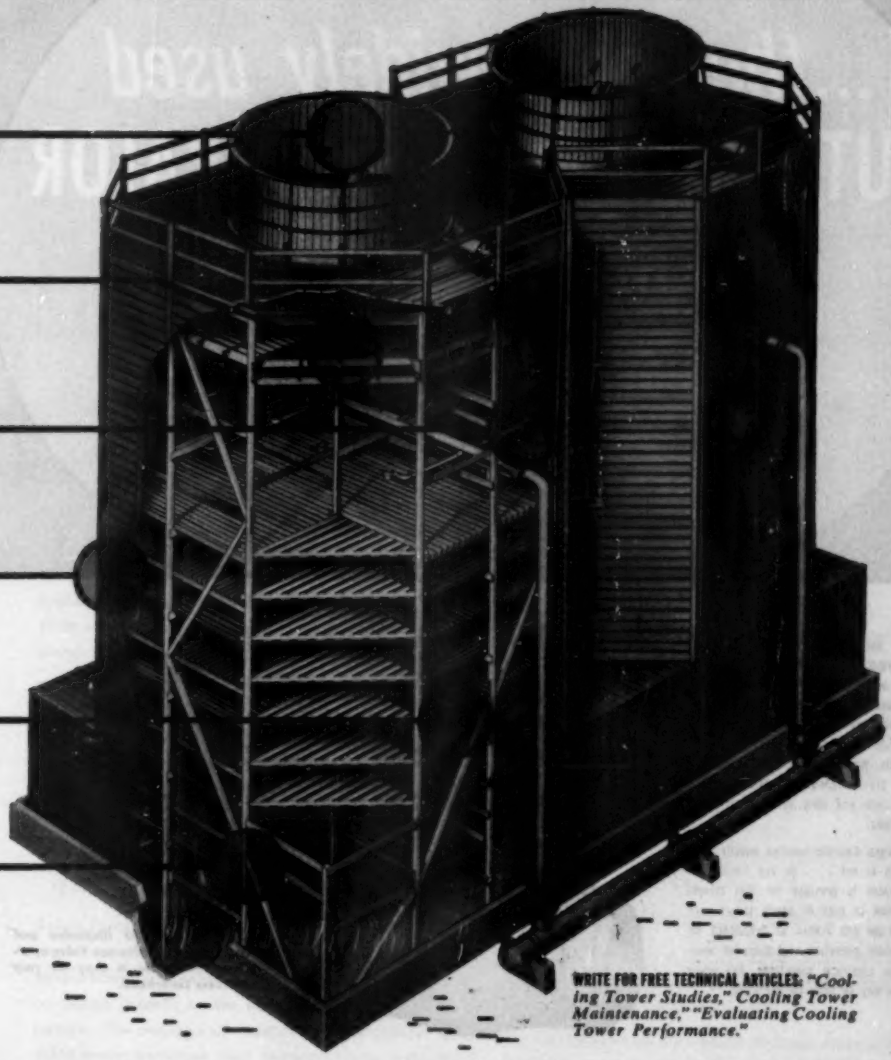
TOWER STRUCTURE

BE SURE WITH FLUOR



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LIMITORQUE®

...the most widely used AUTOMATIC VALVE OPERATOR in the world

In all parts of the world, thousands of Limitorque Controls are in use for automatic or remote operation of valves of all types. Many of the leading Refineries and world famous Petroleum and Gas Pipe Lines are users of Limitorque Controls. Why? Because Limitorque Operators are designed to provide dependable, safe and sure valve actuation at all times.

Limitorque Controls function equally well, indoors or out . . . in any weather. A handwheel is provided for fast manual operation in case of power failure, and Limitorque can always be declutched for handwheel operation regardless of weather or electrical conditions. Any power source may be used for operation.

Our catalog L-90 illustrates and describes the Limitorque Valve operators. Write for a copy on your Business Letterhead.

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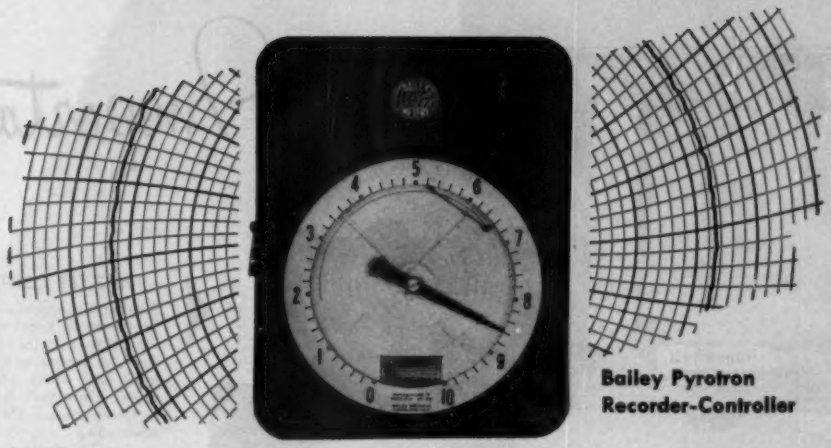
Industrial Gears and Speed Reducers
LimiTorque Valve Controls



Bailey Pyrotron
Recorder-Controller

Looking for Better Temperature Instruments?

. . . Then check these features of Pyrotron Electronic Resistance Thermometers . . .

FUNDAMENTAL ACCURACY

Bailey Pyrotron Resistance Elements are made of highest purity platinum—the material used by the National Bureau of Standards in establishing basic standards for temperatures from −190°C to +660°C.

THREE TYPES OF CONTROL

Pyrotron Controllers may operate: on-off electrical systems by either electronic relays or electric contacts, modulated electronic systems, or air-operated systems. Two temperatures may be recorded on the same chart and controlled by a single instrument.

FACTS PUT INTO USABLE FORM

Bailey Pyrotrons may be arranged to put temperature facts into convenient usable forms. If two or more temperatures are related, they may be recorded as continuous records on the same chart for easy comparison. The average of several temperatures or the difference between two temperatures may be recorded as a single continuous record which may be retransmitted to a distant point or used to actuate a control system.

EASY INSTALLATION

Bailey Pyrotrons do not require careful leveling or protection against vibration. Three ordinary copper wires are all that is needed to connect each temperature sensitive element with the recorder. Power may be taken from any 115 volt 60 cycle circuit.

MINIMUM MAINTENANCE

The absence of galvanometers, batteries and standardizing equipment, together with the use of interchangeable unit assemblies, reduces Pyrotron maintenance to the vanishing point.

ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

For the full story on this unusual electronic resistance thermometer which is suitable for ranges between −300°F and 1200°F, ask for Bulletin No. 230-C. P-21

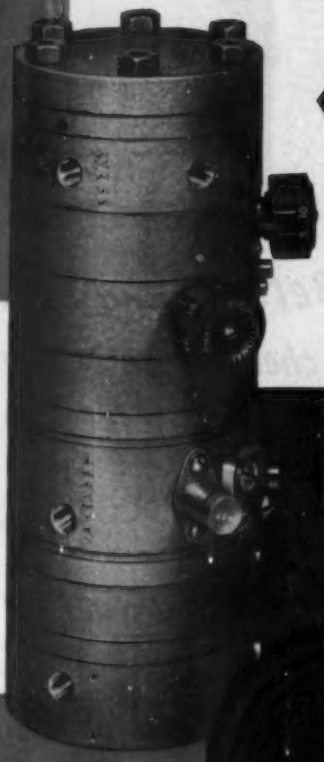
BAILEY METER COMPANY

1043 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE FLOW
PRESSURE LEVEL
% OXYGEN DENSITY
% COMBUSTION RATIO

Important

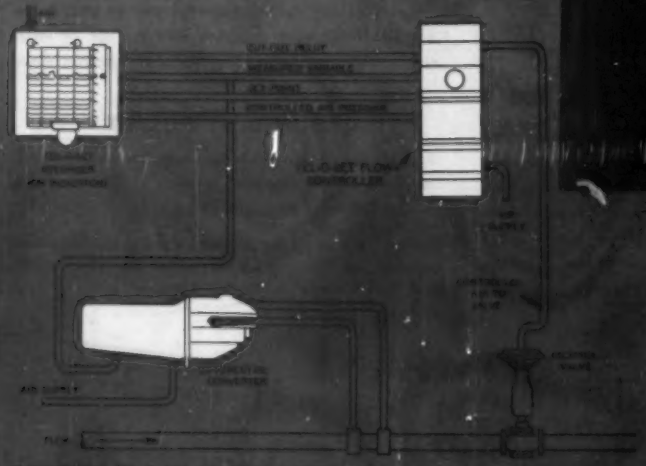


TEL-O-SET CONTROLLER

Available in adjustable and fixed proportional band models, and with three control forms . . . for flow, temperature, pressure, level and other process variables. Universal bracket permits optimum flexibility in mounting . . . coded, interchangeable sections and split manifold contribute to simplified maintenance. Write for Specification Sheet No. 768.

TEL-O-SET RECORDER

Features withdrawal of chassis for full 8-hour chart visibility without interrupting operations, bumpless shifting from automatic to manual operation, all adjustments from front of panel, built-in adjustable restrictions for pulsating flow . . . requires panel space just 5 1/16" high by 5" wide. Write for Specification Sheet No. 769.



TYPICAL ENGINEERED *TEL-O-SET* CONTROL SYSTEM—Pictured in this diagram are the elements of the *Tel-O-Set* Family, designed and built as an integrated loop. Here the system is applied to the control of flow with the *Differential* Converter used as transmitter.

TEL-O-SET INDICATOR

Can be used with any pneumatic transmitter, having a 3-15 psi controlled air output, regardless of the primary element being used. Provides indication of process variable, set-point of controller or controlled air pressure to valve when on automatic control . . . is easily shifted to manual operation. Panel cut-out size same as recorder. Write for Specification Sheet No. 770.

Contribution to Process Control

. . . THE HONEYWELL TEL-O-SET FAMILY

THIS pace-setting pneumatic control system is ready for application to a host of processes demanding a new high in speed, precision and accuracy . . . for almost any process variable. Developed as part of a family relationship, each unit complements the others in producing a system of superior performance.

Used with any one of a group of Honeywell measuring elements . . . for flow, temperature, pressure, liquid level, etc. . . . the *Tel-O-Set* system is destined to make important contributions to the improvement of process control throughout industry.

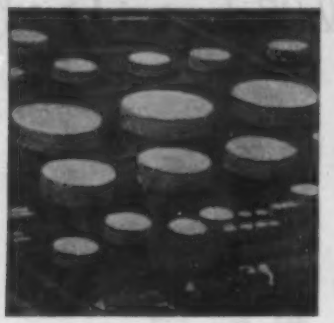
For more detailed information, send for the literature mentioned in the descriptions at left . . . or call in our local engineering representative for a discussion of your process control problems.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4498 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

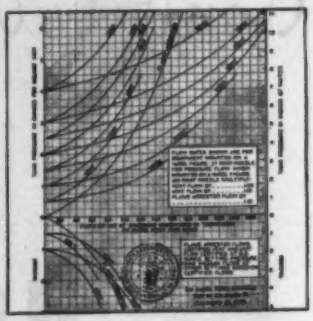
Brown Instruments

1. ***Determine your requirements.***
Calculate maximum gas flow for each tank with A.P.I. Proposed Standards, "VAREC" Venting Formula, or other accepted method.

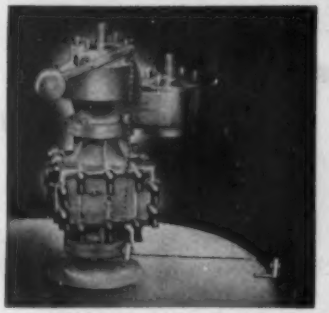


2. ***Select the proper equipment.***
Consider maximum tank working pressure and vacuum for optimum valve settings, materials of construction for corrosion problems, extra fire precautions, etc.

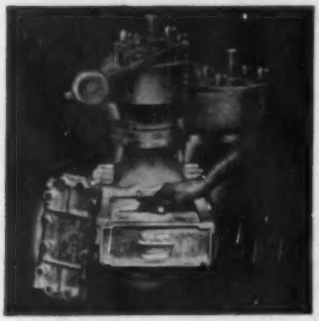
3. ***Buy extra flow capacity.***
Size your valves on the basis of certified flow capacity. Take advantage of extra capacity in "VAREC" Vent Valves and Units.



5 STEPS TO SAFE TROUBLE-FREE TANK VENTING



4. ***Install Properly.***
Use "VAREC" Mounting Nozzles or Nipples to insure full-flow foolproof installations; also "VAREC" Souffer Pulleys to eliminate a makeshift installation.



5. ***Maintain Regularly.***
Inspect regularly to insure continued trouble-free operation. All significant and working parts of "VAREC" Vent Valves and Flame Arresters are readily accessible for easiest inspection and maintenance.

When you follow these five illustrated steps you're sure of a tank venting installation that's going to remain safe and trouble-free. Remember, "VAREC" Engineers are always available to: Aid in determining your venting requirements; help you select the proper equipment; recommend solutions to any of your special venting application problems.

Your copy of the new "VAREC" Tank Venting Equipment Bulletin CP-2001 is ready for you . . . please write today or call your nearest "VAREC" representative.

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YES **THEY CAN,** in spite of shortages and slow deliveries on many stainless materials.

For verification, see the picture at the right—a carload of *ESCO* stainless piping recently shipped to a well known manufacturer. Piping is made up entirely of *ESCO*'s cast stainless fittings and Spuncast pipe.

This centrifugally cast pipe is produced in a wide variety of standard and special analyses, and in schedule 40 wall or heavier. It is superior in resistance to corrosion, in withstanding wear or abrasion, and in mechanical strength. And under present regulations...

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Also available are stainless castings, valves, pipe fittings, flanges, etc.

Full information on *ESCO* Spuncast pipe is contained in our new catalog "Stainless and High Alloy Products". If you don't already have a copy, we suggest you get one from your nearest *ESCO* representative; or send us the filled-in coupon.

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● It is easy to understand why it took more than a rigger's version of "Geronimo" to set this giant propane tank "paratrooper"—and five more like it—snug aboard the S.S. Paolina . . . its 70′10″ length would cover a strip on a big-league diamond from pitcher's slab to the end of the catcher's box, 10 feet behind the plate. Its 103″ I.D. would allow a pitcher's full stretch . . . a batter's full swing.

Big-league delivery is an old Sun Ship custom. For more than 30 years its great plant has been making equipment for petroleum refineries—small tanks, fractionating towers, stills, pressure vessels, cracking cases, reactors, kilns, condensers, and machinery for all types of oil cracking and treating systems . . . And Sun Ship riggers have seen to it that they arrive . . . anywhere in the world . . . by ship, rail or truck . . . as ready for service as a paratrooper.

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SHIPBUILDING & DRY DOCK COMPANY

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25 BROADWAY • NEW YORK CITY

Make H_2SO_4 from H_2S

WITH A CHEMICO PLANT

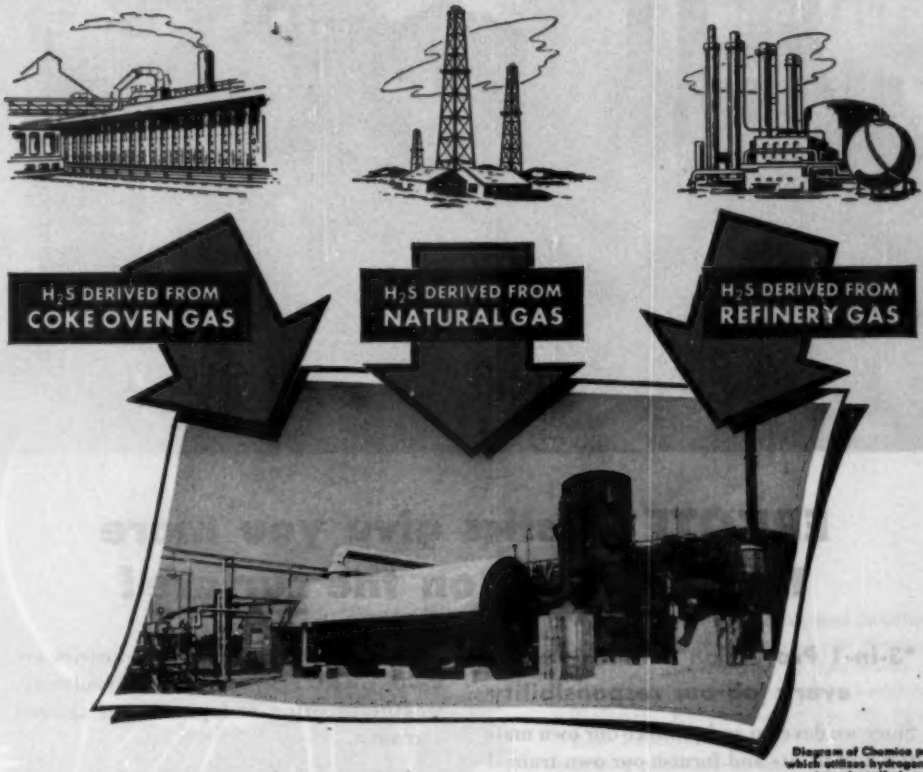
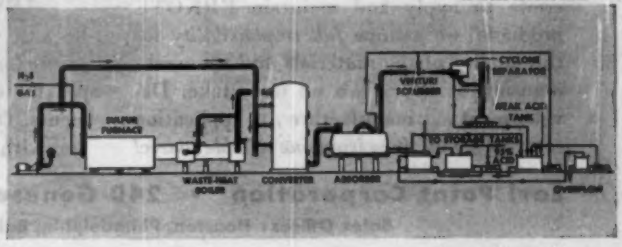


Diagram of Chemico process which utilizes hydrogen sulfide to make sulfuric acid.

Now that raw sulfur is in short supply, it has become necessary to manufacture sulfuric acid from other raw materials such as hydrogen sulfide. If you have hydrogen sulfide available, it will pay you to investigate Chemico's practical and proven process for making H_2SO_4 from H_2S. Chemico's new type sulfuric acid plant is especially well suited for this purpose. Or existing sulfuric acid plants can be converted.



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Chemico plants are profitable investments

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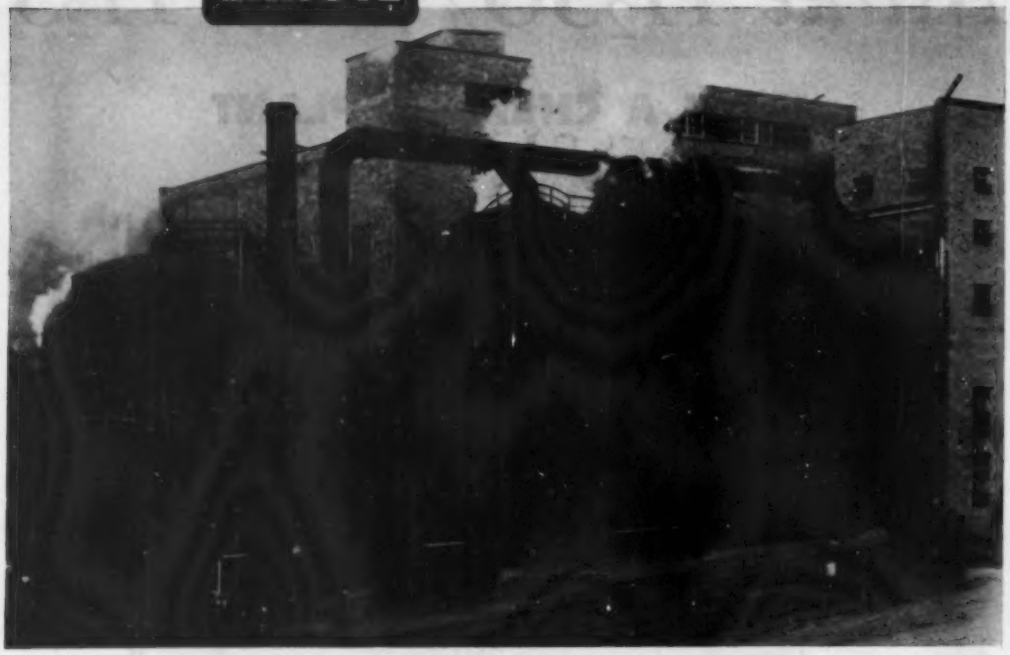

ERKOTE Mastics give you more than appears on the surface!

"3-in-1 Protection" makes every job our responsibility

Since we develop and produce our own mastics and paints and furnish our own trained crews to apply and maintain ERKOTE products, we assume *full responsibility* for the quality of the materials and the workmanship on every job we undertake. Development . . . manufacture . . . application . . . you get *all three* from *one reliable source!*

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Because we manufacture both mastics and paints for industrial protection, we can supply the exact coating to satisfy your requirements. Our engineers will be glad to help you with our recommendations.

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FOR USE WHERE PAINTS FAIL

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Corrosion Resisting Mastics, Mica Mastics, Insulating Mastics, Vapor Seals, Troweling Mastics, Color Finishers, Industrial Paints and Varnishes.

55 GALLONS OF EMULSION-BREAKER

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Visco... CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating Compounds for use in the breaking and resolving of oil emulsions, or to grant licenses for such use, under the following United States Letters Patent: 2,050,669; 2,050,640; 2,206,139; 2,214,703; 2,214,704; 2,235,139; 2,260,414; 2,307,313; 2,318,024; 2,318,025; 2,321,864; 2,328,254; 2,454,809; 2,514,299. Visco Products Company is willing to grant licenses on a royalty basis, to oil companies, and to others desiring to practice the patented subject matter, under any and all of the above Letters Patent, permitting the user to purchase the oil treating compounds at will from any vendor, or to prepare the compounds for use or to use the compounds under the above Letters Patent. Application for license should be made to: Visco Products Company, Houston, Texas.

Outstanding in its Field...

Leading Refiners Are Switching to KAYLO HEAT INSULATION

Kaylo Heat Insulation not only *stands out* in performance and ease of application—it has the ability to *stand up* under tough service conditions. This revolutionary heat-saving material is a hydrous calcium silicate (not glass).

Kaylo Heat Insulation is inorganic, incombustible and insoluble in water. Its wide *effective* temperature range—up to 1200°F.—eliminates the need for combination coverings in nearly all operating conditions.

Breakage, too, in transit or on the job, is practically eliminated. The high strength of Kaylo Heat Insulation even permits workmen to walk on insulated equipment. Yet with its high strength, Kaylo Heat Insulation is lightweight—easy to handle and apply.

These are but a few of the reasons why leading refiners are *switching* to Kaylo Heat Insulation. For complete details on Kaylo Heat Insulation, write Dept. N-170, Owens-Illinois Glass Company, Kaylo Division, Toledo 1, Ohio.

The oil industry's newest processing and gas cycling plant, Elk City, Oklahoma operated by Shell Oil Co., Inc., on behalf of itself and eight other companies. Kaylo Heat Insulation is used throughout the entire installation.

KAYLO PIPE INSULATION is made to Simplified Dimensional Standards of thicknesses and diameters for snug nesting, when necessary. Coverings are sectional for tube and pipe sizes ¼" to 12"; tri-segmental up to 23"; quad-segmental up to 41"; K-segmental (18" wide segments) up to 72" in diameter.

KAYLO HEAT INSULATING BLOCK is made in all standard sizes and thicknesses from 1" to 6" for flat surfaces and for vessels larger than 60' in diameter; curved block 18" wide for smaller vessels.

KAYLO® ... *first in calcium silicate*

SEE OUR CATALOG IN THE REFINERY CATALOG

...*pioneered by* OWENS-ILLINOIS Glass Company

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Up-to-the-minute data on pressure vessel outlets

IN THIS new Pressure Vessel Catalog 501 you will find the latest data covering pressure vessel outlets compiled as you would expect it to be by the originators of forged and rolled steel welding necks and nozzles.

The pages include up-to-the-minute information on seamless steel nozzles, welding necks, manways, and large diameter flanges for boilers, heat exchangers, and other pressure vessels. Of particularly timely importance are data covering standards of Tubular Exchangers Manufacturers Association (TEMA Standards). A useful section on modern flange design covers codes, materials, and design procedures with typical calculation forms and examples of calculation.

This 118 page book is available without charge to anyone having a specific interest in outlets for pressure vessels. To obtain your copy see your Taylor Forge Distributor or **MAIL THE COUPON.**

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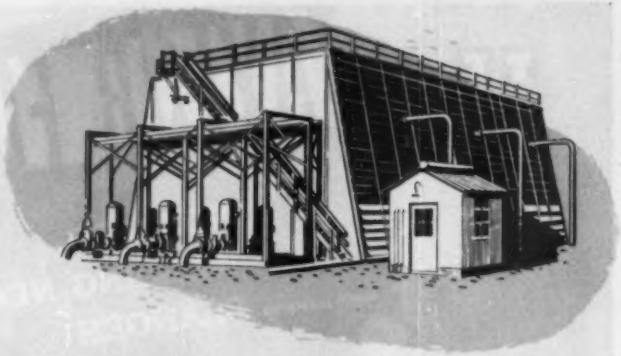
For day in, day out *dependability*—you can't beat a



BJ VERTICAL COOLING TOWER PUMP

FOR REFINERY OPERATION — these pumps have what it takes to handle 'round-the-clock, seven-days-a-week, 52-weeks-per-year pumping! Because they are *BJ engineered*, you can be sure they'll measure up to your cooling tower requirements. Because they are *BJ built*, you can be sure of steady-going, low cost operation that won't let you down.

These are some of the features that make BJ Vertical Cooling Tower Pumps dependable performers: *Rigid alignment*—all parts are machined with shoulders and recesses to form metal to metal joints. *Self-priming*—the self-contained pumping unit takes suction from the pit in which it is mounted. *Simple installation*—vertical suspension saves space and cuts installation cost. *Saves piping*—pump element is suspended on a welded steel discharge column with the motor mounted at the top of the column and direct coupled to the driver shaft. Capacities to 7500 gpm and heads as required. Furnished with motor or to fit motor you have.

Ask your local BJ representative or send the coupon below for details.

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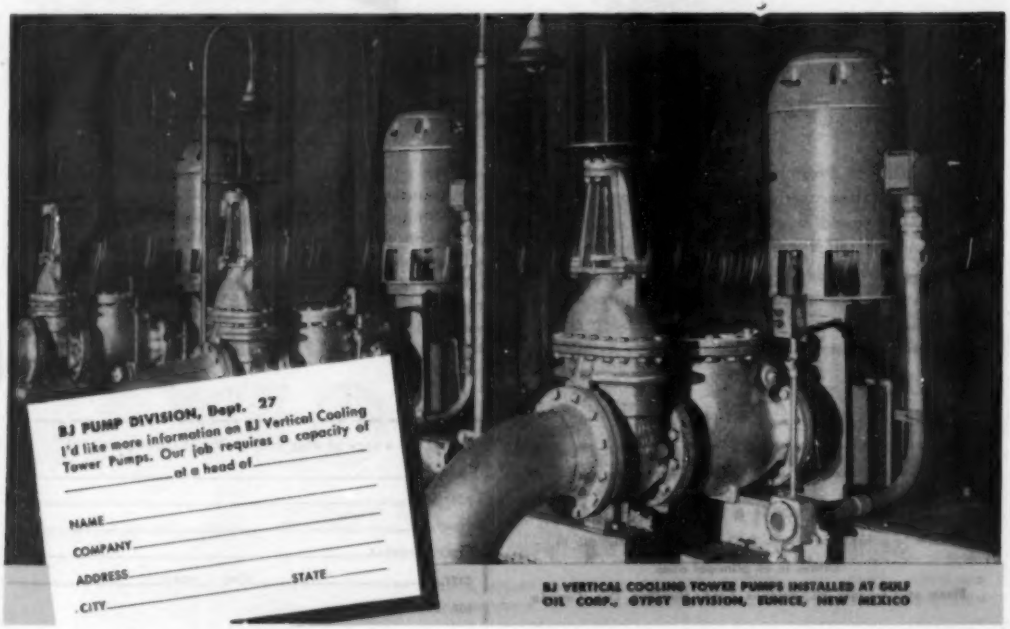

BJ PUMP DIVISION, Dept. 27
I'd like more information on BJ Vertical Cooling Tower Pumps. Our job requires a capacity of _____ at a head of _____

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Lasts longer in corrosive service

If the application is on a line carrying corrosive liquids, a high alloy valve will save you time and trouble. ALOYCO specializes on high alloy valves with

A. metallurgical research devoted *exclusively* to corrosive applications;

B. foundry and machine shop facilities set up for high alloy valves *only;*

C. casting and machining practices dictated by the difficult characteristics of the alloys required for corrosive services.

Success Stories from ALOYCO'S Corrosion Clinic

THE CORROSIVE: Asphalt resin.

THE APPLICATION: Sampling high-temperature, high-viscosity asphalt resin in processing of lubricating oil.

THE PLACE: A large oil refinery.

THE PROBLEM: Standard cast iron gate valves, traced with a 150 psi steam coil, did not provide uniform heating, which gave trouble in sampling. They became loaded with asphalt, which caused them to stick. When finally opened, a solid slug of asphalt would come through.

THE SOLUTION: ALOYCO fully jacketed gate valves. Valve body and bonnet jackets are connected to 150 psi steam and valves are completely lagged.

Steam-jacketed ALOYCO valve insures free-flowing asphalt resin sample.

THE RESULTS: ALOYCO valves have been in service since 1948, and are used daily for sampling. Since valve is heated uniformly in body and bonnet, the asphalt flows freely and sticking is eliminated.

THE BACKGROUND: The ALOYCO Corrosion Clinic offers aid on all sorts of problems—not just corrosion. If the service is one that should be handled by a corrosion-resistant valve, the problem—whether it be corrosion, contamination, discoloration, temperature extremes or proper application—is one for the Clinic.

Among all valve manufacturers, ALOYCO is the *largest* specializing in high alloy valves. We make *more* corrosion-resistant valves than anybody else.

Cut valve costs. Put your problem up to ALOYCO'S Corrosion Clinic.

ALLOY STEEL PRODUCTS CO., INC.

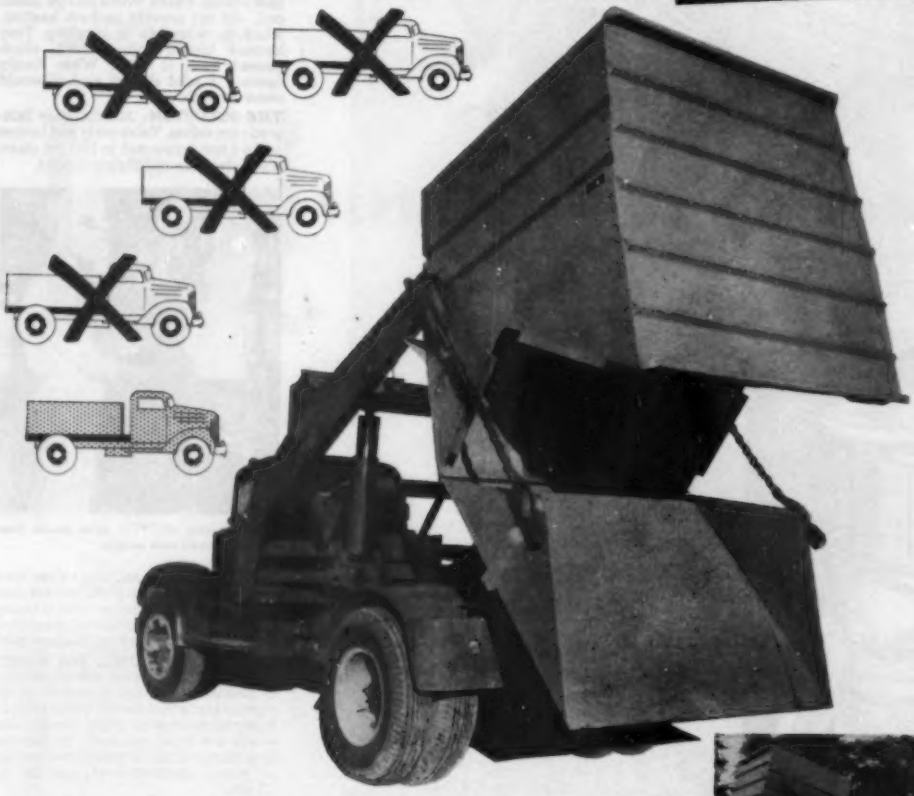
Longer Lasting

ALOYCO VALVES

1st in Corrosive Service

You Can Do The Work of 3 to 5 Conventional Trucks With Only One

DEMPSTER DUMPSTER

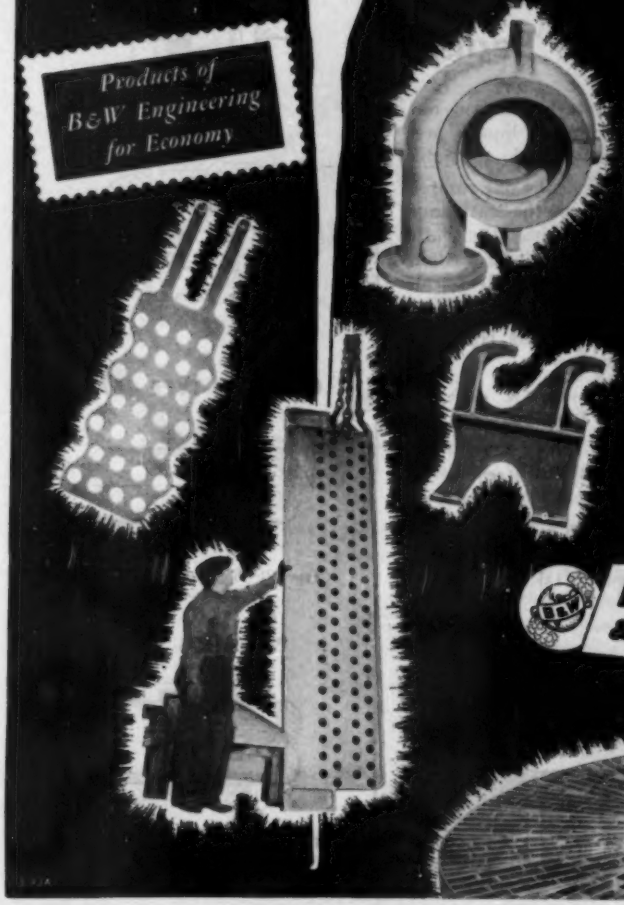


In many plants handling materials by the Dempster-Dumpster System, one truck-mounted Dempster-Dumpster, operated by only one man, the driver, has replaced 3 to 5 conventional trucks and crews. One Dempster-Dumpster services a multiple number of detachable containers in a wide variety of designs best suited to the type of materials handled—be they bulky, light or heavy . . . solids or liquids . . . trash or rubbish. Containers are conveniently located at accumulation points inside and outside buildings. The Type LFW Dempster-Dumpster shown above handles containers up to 12 cu. yds. Containers up to 21 cu. yds. are available with our Type ARLF and DTLF Dempster-Dumpsters. Without question, the Dempster-Dumpster System is the most economical and most efficient method of plant materials handling by truck yet devised! Write today for complete information. Manufactured exclusively by Dempster Brothers, Inc.

DEMPSTER-DUMPSTER, operated by means of hydraulic controls in cab, picks up each container, hauls and empties it or sets load down intact.

DEMPSTER BROTHERS, 5121 Dempster Bldg., Knoxville 17, Tennessee

Let B&W pour LONGER LIFE into YOUR processing equipment



As vital parts in many types of petroleum processing equipment, B&W Alloy Iron and Steel Castings are demonstrating outstanding ability to resist abrasion, corrosion, and oxidation, and to retain high strength even at elevated temperatures. Operating in just about every kind of tough service, they are helping to keep production up by reducing costly, time-consuming repairs and replacements. Their long-life characteristics have been proved over and over in service temperatures up to 2000 F. and under conditions requiring high creep strength and wear-resistance.

Might pay you, as it has so many others, to call on our broad experience in solving processing problems with heat-resistant and wear-resistant alloy castings from our own modern foundries. The Babcock and Wilcox Co., 85 Liberty St., New York 6, N. Y.

BABCOCK & WILCOX

Garlock
"Chevron" Seal

Wherever leakless operation is required—specify GARLOCK Mechanical Seals

When leakless operation of centrifugal or rotary pumps is required—particularly, if corrosive or inflammable liquids are being handled—GARLOCK Mechanical Seals will do the job.

These seals are composed of two main elements; one rotates with the shaft and the other is stationary. Since the stationary element does not contact the shaft, there is *no* wear on the shaft. A positive contact between carefully lapped metal-to-carbon or, metal-to-metal mating surfaces provides the leakless seal.

Users of GARLOCK Mechanical Seals have reported outstanding service records on a wide variety of applications. Here are just two taken from the many in our files:

- Over 3 years' service and still in operation, on a 1¾" shaft of a boiler feed pump handling water at 220°F. and 200 p.s.i., and operating at 3600 r.p.m.
- Two years' service, and still in operation, on a 1" shaft of a pump handling paint at 130°F., 10' Hd., operating at 1750 r.p.m.

GARLOCK manufactures mechanical seals in many standard and special designs from a wide range of high quality materials. For more information, write for our Mechanical Seal booklet or call your GARLOCK representative.

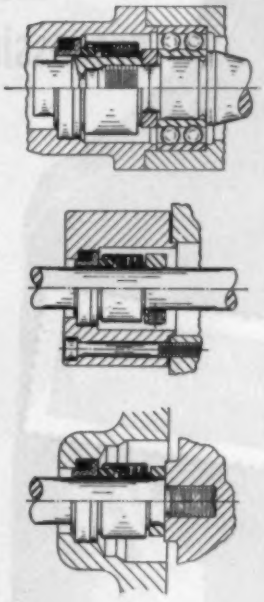
THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

Tulsa, Okla. Houston, Tex.
Los Angeles, Calif.

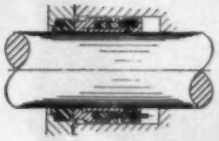
GARLOCK

TYPICAL APPLICATIONS of GARLOCK Mechanical Seals for Rotary Shafts

PACKAGE SEALS

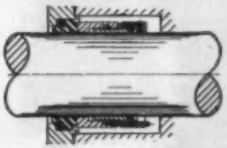


CHEVRON-TYPE SEALS



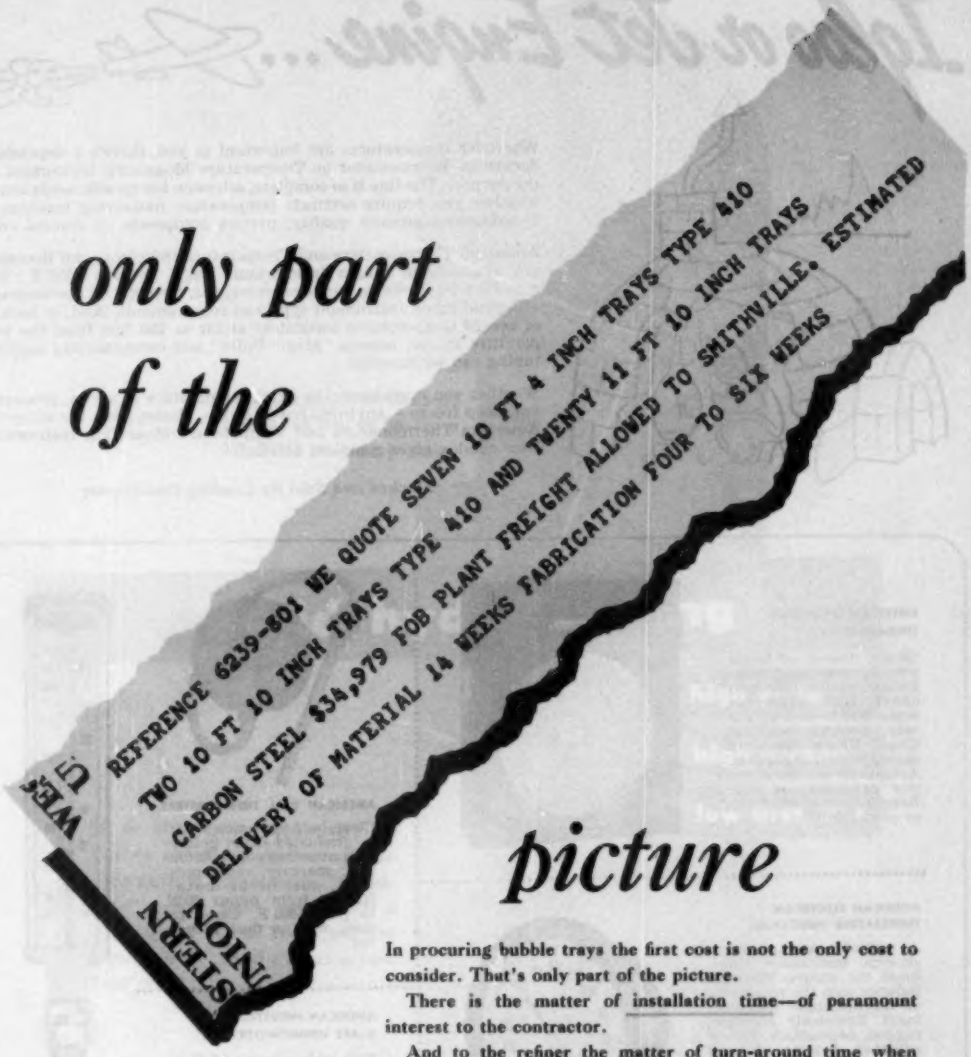
Type CB—Balanced "Chevron" Seal

"O" RING SEALS



Type OB—Balanced "O" Ring Seal

only part of the picture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REFERENCE 6239-801 WE QUOTE SEVEN 10 FT 4 INCH TRAYS TYPE 410
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CARBON STEEL $34,979 FOB PLANT FREIGHT ALLOWED TO SMITHVILLE. ESTIMATED
DELIVERY OF MATERIAL 14 WEEKS FABRICATION FOUR TO SIX WEEKS

In procuring bubble trays the first cost is not the only cost to consider. That's only part of the picture.

There is the matter of installation time—of paramount interest to the contractor.

And to the refiner the matter of turn-around time when replacements become necessary is of even greater importance.

Exclusive design features of Gilbarco Bubble Trays and Caps that cut installation costs and turn-around time are today's outstanding advance in fractionating tower internals. Let us give you complete information.

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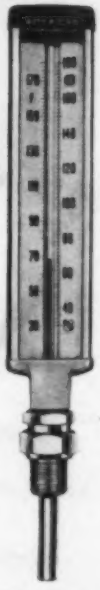
Clear, bold figures on exactly graduated dials; pointer of contrasting color. Actuation: mercury, vapor pressure, gas, or bi-metal. Ranges from minus 60°F. to plus 1000°F. Cases for stem, wall, or flush mounting.



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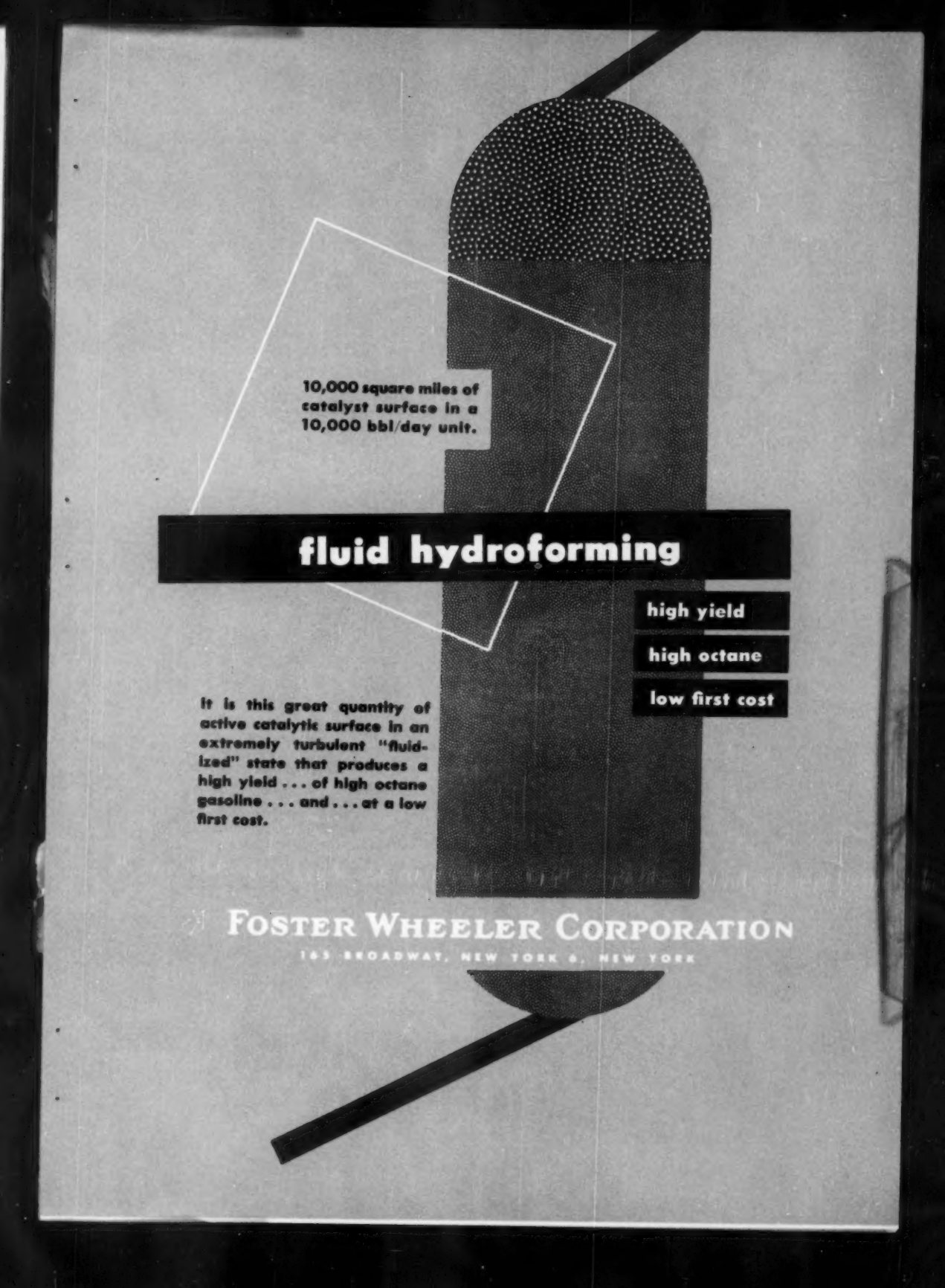
Full scale opening of 7", 9", or 12" with easy-to-read red mercury tubing. Ranges from minus 80°F. to plus 1150°F. Straight and angle forms.

AMERICAN INDUSTRIAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES. BUILDERS OF "SHAW-BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.


10,000 square miles of catalyst surface in a 10,000 bbl/day unit.
fluid hydroforming
high yield
high octane
low first cost
It is this great quantity of active catalytic surface in an extremely turbulent "fluidized" state that produces a high yield . . . of high octane gasoline . . . and . . . at a low first cost.
FOSTER WHEELER CORPORATION
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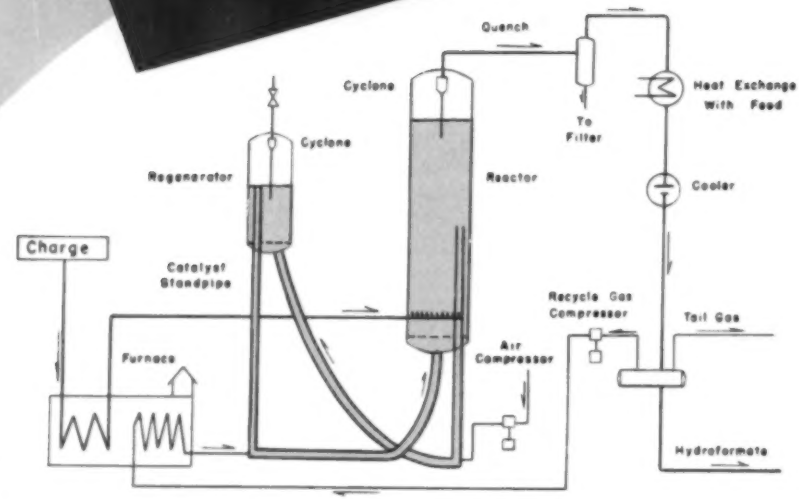
fluid hydroforming



The "fluid" principle, as applied to hydroforming, provides all the distinct advantages of full, continuous operation. Its inherent process variables also makes possible a more exact control of the intensity of the hydroforming reaction.

Foster Wheeler's Fluid Hydroforming Pilot Plant is available for stock evaluation and determination of process design data.

FOSTER WHEELER CORPORATION
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They Resist Corrosion by Most Natural Waters

Whether you use fresh, salt or brackish circulating water, service records testify that Admiralty metal tubes have given very satisfactory performance in refinery service heat exchangers.

Such corrodents as carbon dioxide, hydrogen sulfide, chlorine and metal salts, in the concentrations normally found in natural waters, or used in their treatment, as well as many of the contaminants in crude petroleum, are effectively resisted by tubes made of Admiralty.

Adding as little as 0.02% *Phosphorus* to Admiralty gives maximum resistance to dezincification while retaining all the other desirable properties of this alloy.

In order to assure *uniform* chemical composition and *soundness*, Scovill produces its Phosphorized Admiralty tubes by the continuous billet-casting process which continuously maintains the optimum amount of phosphorus. The tubes are hot-extruded from the continuous-cast billets, then are cold-drawn, annealed, cleaned and finished to produce tubes of uniform temper, gauge, straightness, roundness, diameters, length and freedom from burrs.

A Condenser Tube Booklet is available to qualified users who request it on their business letterhead. Scovill Manufacturing Company, 14 Mill Street, Waterbury 20, Connecticut.

Only Scovill Phosphorized Admiralty Has All These Advantages . . .

- Uniformity and soundness resulting from Scovill continuous-casting techniques
- Relative immunity to dezincification
- High resistance to sulfides and other active sulphur compounds
- Superior performance in fresh, salt, or brackish waters
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- Good resistance to velocities under 7 fps.
- Excellent performance at relatively high operating temperatures

SCOVILL

SCOVILL CONDENSER TUBES

"You can't buy better brass"

A PRODUCT OF SCOVILL

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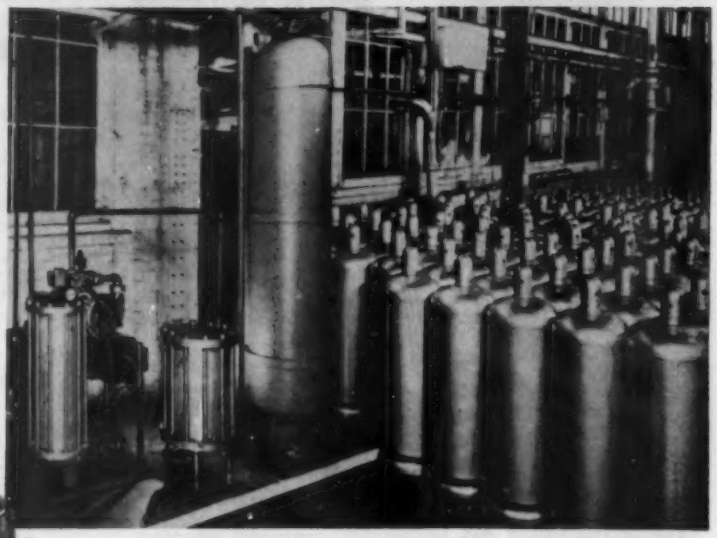
To keep your gas refinery-dry

LP-Gas cylinders are tested with DRY air



This Lectrodryer and Lectrofilter deliver DRY, CLEAN air to the stand where LP-Gas cylinders are given a final test at John Inglis Company, Ltd., Toronto, Ontario.

Lectrodryers like this are placed on-stream in refineries to make the DRYing operations continuous. All functions can be automatic.

Consumers of LP-Gas are increasingly insistent that the gas delivered to them is DRY. Freeze-ups that result from moisture in the gas are hazardous, as well as a bother. That's why John Inglis Company uses air dried by a Lectrodryer* to avoid introducing moisture when testing their gas cylinders.

Refineries are similarly depending on Lectrodryers to DRY their LP-Gas before it goes into storage or shipping containers. Dewpoints of –50° F. are quite common in the industry.

Whether your problem is DRYing gases, air or organic liquids, there's a Lectrodryer to solve it. Our engineers can relieve your men of much of the responsibility on this very specialized work. Lectrodryers have been proved for many years on thousands of DRYing assignments.

Write Pittsburgh Lectrodryer Corporation, 307 32nd Street, Pittsburgh 30, Pennsylvania.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In Australia: Birlec, Limited, 51 Parramatta Road, Glebe, Sydney.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
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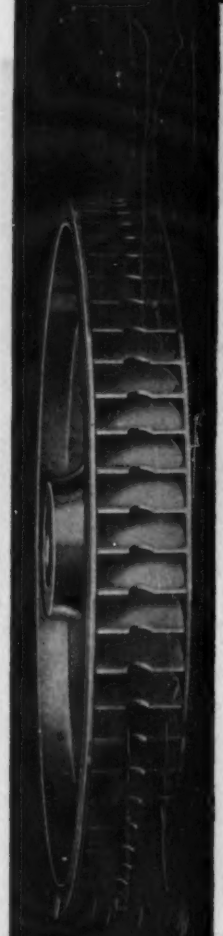
LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

*REGISTERED TRADEMARK U.S. PAT. OFF.

TERRY



BLADE PROTECTION

Made Possible by Nozzle Location

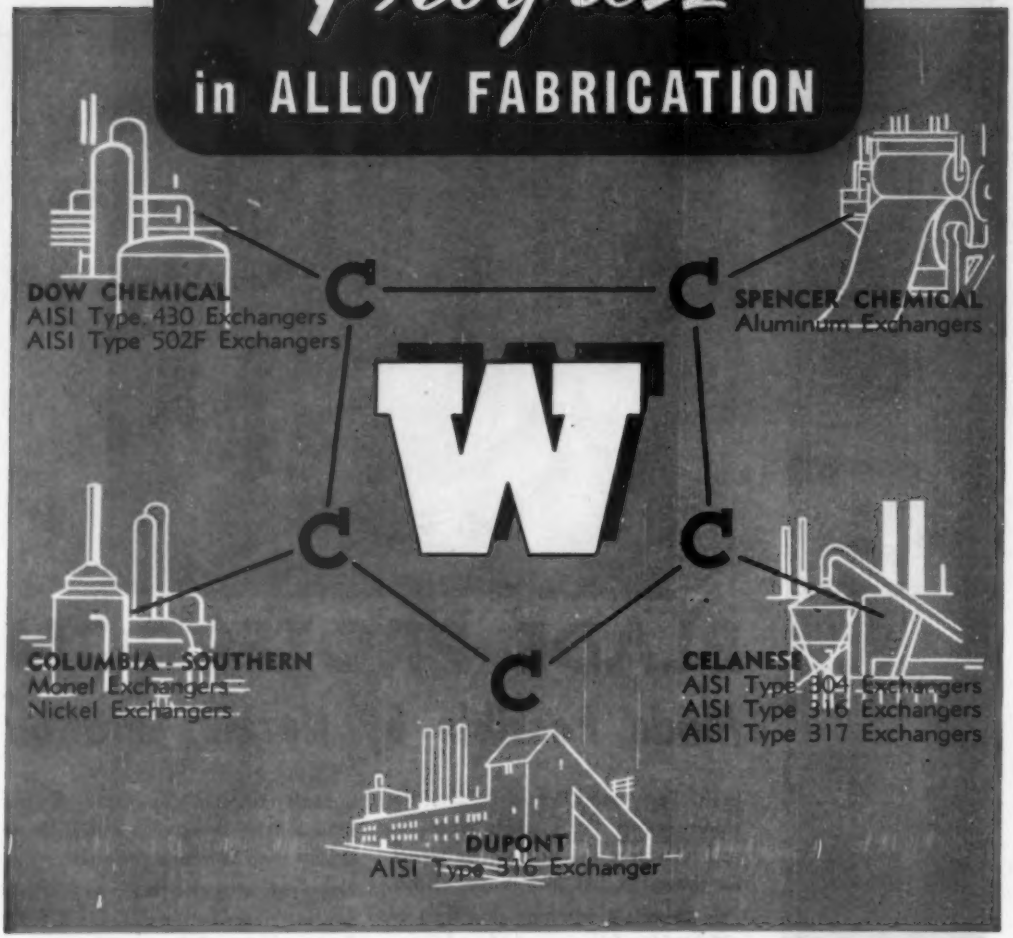
In the Terry Solid-Wheel Turbine, the steam enters the buckets from the top, not from the side of the wheel, as shown in the illustration above. This permits a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though excessive thrust should tend to move the shaft.

This feature and others, as important, are described in detail in Bulletin S 116 which will be sent to you on request.

T-1175

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Symbolic of WESTERN'S *Progress* in ALLOY FABRICATION



Western Supply Company is daily serving the heat transfer needs of the ever-expanding chemical and petrochemical industries with custom construction in all metals. Stainless Steels, Monel, Nickel, Copper . . . each plays its important part in the economical and efficient performance of heat transfer equipment within the highly diversified chemical processing industry. Consult with WESTERN engineers on ALL your heat exchanger needs.

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SAN FRANCISCO REPRESENTATIVE: TRIDENT ENGINEERING COMPANY

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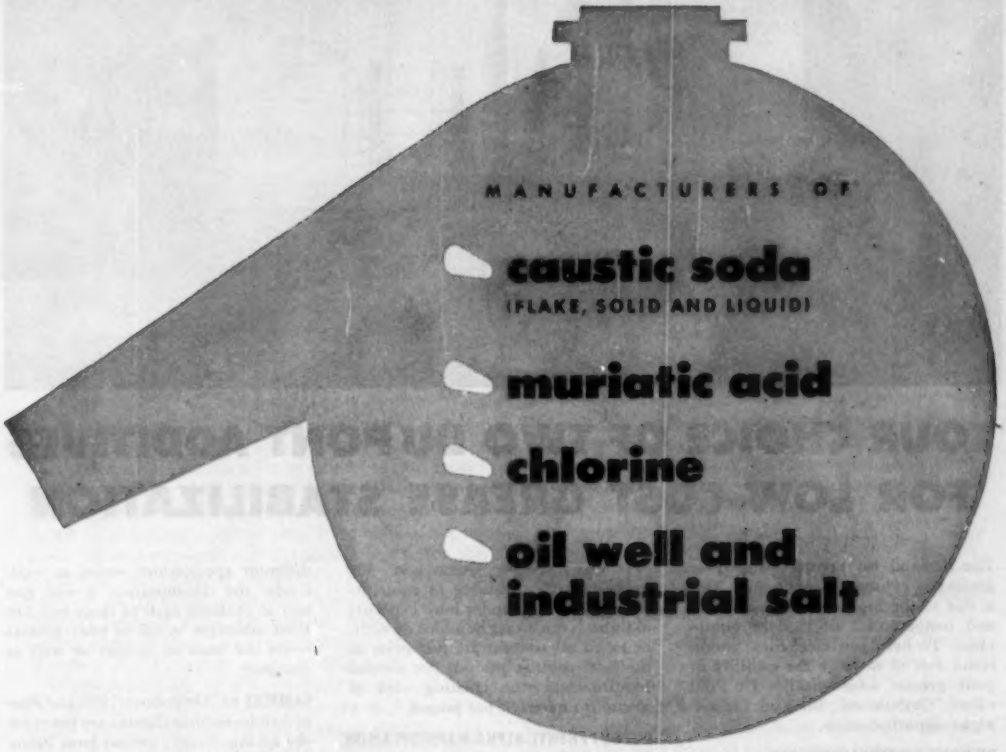

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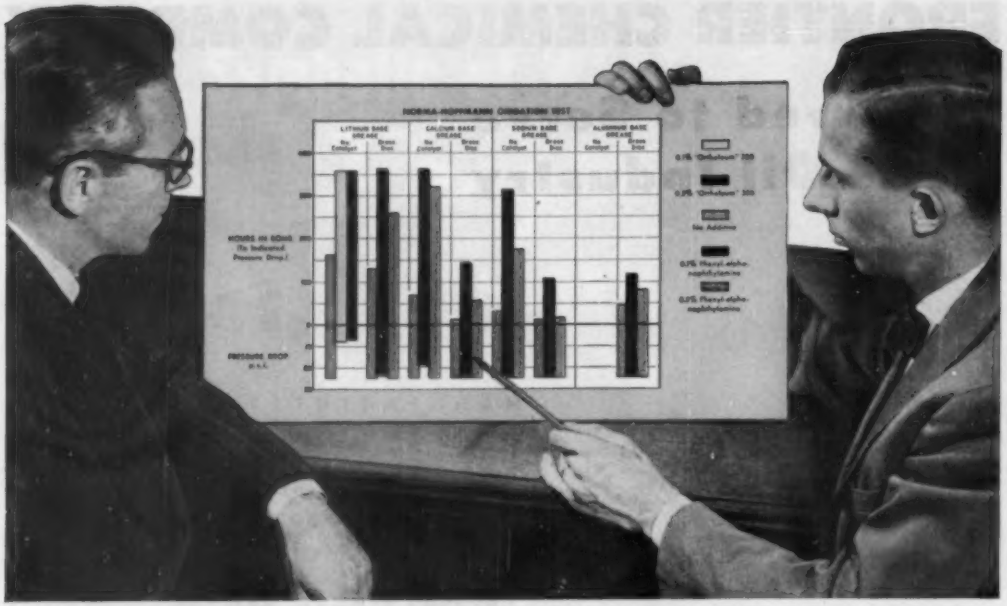

YOUR CHOICE OF TWO DU PONT ADDITIVES FOR LOW-COST GREASE STABILIZATION

The demand for greater stability in greases is constantly increasing. This is due to the higher operating speeds and temperatures of modern equipment. To help you meet these conditions, and to increase the stability of your greases economically, Du Pont offers "Ortholeum" 300 and Phenyl-alpha-naphthylamine.

DU PONT "ORTHOLEUM" 300 supplies both antioxidant and metal deactivating properties. The result of this combination is outstanding where metal catalysis is a factor. On the other hand, "Ortholeum" 300 also shows marked superiority over Phenyl-alpha-naphthylamine in many non-catalyzed systems, as indicated in the Norma Hoffman comparison.

In many greases "Ortholeum" 300 provides high resistance to color deterioration, even under long exposure to light. It can either be added directly, or in an oil concentrate just prior to the final cooling period. For normal requirements, the treating cost of grease is under ½¢ per pound.

DU PONT PHENYL-ALPHA-NAPHTHYLAMINE gives excellent results in most non-catalyzed systems when the superior color stability of "Ortholeum" 300 is not essential. In equal concentrations, its lower price per pound means lower treating costs, too.

Since greases vary widely in their composition, their response to different stabilizers varies also, and the degree of stabilization required for different applications varies as well. Under the circumstances it will pay you to evaluate each of these two Du Pont additives in all of your greases —on the basis of quality as well as economy.

SAMPLES of "Ortholeum" 300 and Phenyl-alpha-naphthylamine are yours for the asking. Simply contact your Petroleum Chemicals Representative, or address your request to the Du Pont District Office nearest you.

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IN CANADA: Canadian Industries Limited—Toronto, Ont.—Montreal, Que.

For More Oil, More Steel

TO THE OIL MAN, the formula for increased oil production and refining is contained in the simple statement, "You give us the steel and we'll give you the oil." PAD's request for 9.8 million tons of steel for the oil industry operations, as a "minimum," is still under consideration by the Defense Production Administration, which has the power of allocation. A breakdown of the figure shows that the request allows a six percent expansion of operating levels for the industry, including a 350,000-barrel-per-day expansion in refining capacity. Also included was 862,000 tons of steel for use of American companies outside the U. S., representing a 35 percent increase above current usage in this year.

With shipments of Middle East and Caribbean Oil diverted from the United States to Europe to cover the shortage of former Iranian supplies, the U. S. oil companies are meeting increasing difficulties in their efforts to find crude at Gulf Coast points. In fact, the crude situation has become so tight that their purchases have been reduced to a point far below the loss from outside sources. While the first demands resulting from the Iranian shut-down have been met by withdrawals from stocks of products, this drain cannot be withstood if the Iranian stalemate continues beyond the end of 1951.

Such measures as increased production in other parts of the world, tariff reduction on crude imports, further exploration in Alaska, and the settlement of the tidelands issue are matters under consideration to relieve the demand for oil; however, none of these programs will net increased supplies unless steel is provided for expansion of both production and refining facilities.

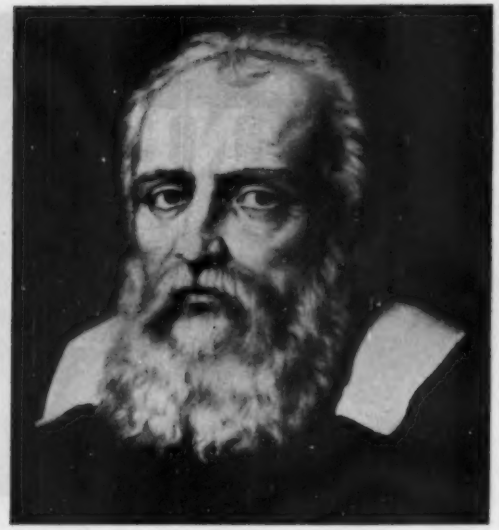
The proposal by Secretary Chapman to create a $400 million coal-to-oil industry and a $50 million oil-shale-to-gasoline plant is presently under consideration by the House Commerce Committee. As oil men in PAD and elsewhere have pointed out, this project is not sound economically; and though Chapman asserts the project would require no more steel than to make the same amount of petroleum products from crude, the point is that the steel is not available.

History of Synthetic Fuels

IN 1866, only seven years after Col. Drake's successful venture at Titusville, Pa., the U. S. Revenue Commission said synthetic-produced fuels would be available if oil production should end. In 1951, 92 years and 43,362,923,000 barrels of oil production later, Secretary of the Interior Oscar L. Chapman has sighted the last drop of petroleum; but unlike the other prognosticators, he is ready to take remedial action, backing up his belief with a substantial sum of the taxpayers' dollars. To provide the incentive for initiating a commercial synthetic fuels industry, Chapman requested in the name of national defense that $455 million be set up as government "borrowing power" to back up the proposed coal hydrogenation and oil shale production with taxpayer-guaranteed price floors. His request recently was reduced to $100 million under the terms of the revised Defense Production Act.

Chemically, the chief difference between coal and petroleum is that the latter has a higher hydrogen content. Coal, with the proper injection of hydrogen, can be made to produce the same products as are now provided in ample supply by oil. Economically, the difference between gasoline made from coal and from crude oil is either 30.5

Top-of-page Photo: Lights outline fractionating towers and surrounding structures at the Cities Service refinery, Lake Charles, La. (Photo, courtesy "Service" magazine.)



How many do

Whether you recognize the first three faces or not, we think you'll know the fourth one. There are thousands of these Taylor FULSCOPE* Controllers in service today, in almost every process industry from chemicals to milk, from petroleum to plastics.

A Taylor FULSCOPE Controller is a rugged, dependable air-operated instrument for control of temperature, pressure, flow, liquid level, density, load and humidity. It was the first controller on the market with completely interchangeable unit construction.

All parts are interchangeable, and every FULSCOPE case is drilled and tapped to hold the most complete set of control responses. Simple controllers can be converted into the most complex, if necessary, right in the field; repairs can be made quickly by your own instrument man.

*Reg. Trade-Mark

The six standard types of FULSCOPE Controllers fit almost any processing need:

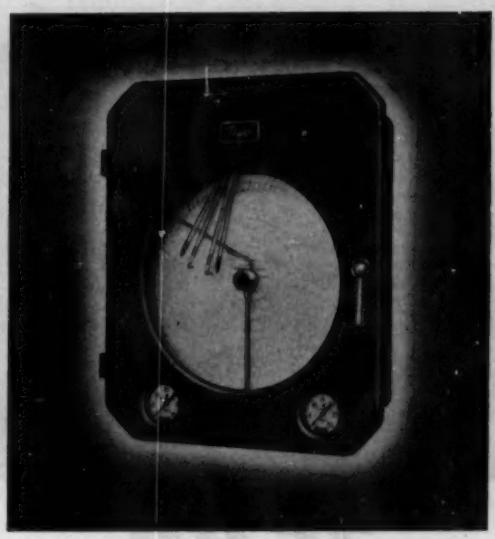
1. For simple on-off control on applications with small time lags and large capacities, regardless of load change, buy a *Fixed High Sensitivity* model.

2. For throttling control on similar applications, you need *Adjustable Limited Range Sensitivity.*

3. Throttling control where you have a wide range of time lags and capacities, infrequent or negligible load changes, calls for *Full Range Adjustable Sensitivity.*

4. Precision control under a wide range of time lags and capacities, with gradual, sustained load changes, calls for *Adjustable Sensitivity with Automatic Reset.*

5. Where there are momentary disturbances, but no sustained load changes, get *Adjustable Sensitivity with Pre-Act.*



you recognize?

6. To meet almost any control problem, get the FULSCOPE Controller with all three control effects: *Adjustable Sensitivity, Pre-Act* and *Automatic Reset.* It gives precision control on applications with a wide range of time lags and capacities, and sudden, sustained load changes.

Ask your Taylor Field Engineer how FULSCOPE Controllers can help solve a big majority of your control problems, protect product quality and save money too. Write for Bulletin 98151.

Where pneumatic transmission is preferred, and particularly where graphic panels are wanted, ask about Taylor's revolutionary new three-part TRANSET* Control System too. Write for Bulletin 98097. Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.*

Still wondering who the men are? All are founding fathers of the instrument industry. First on the left above is Torricelli, who made the first barometer. Next is Galileo, maker of the first thermometer, and then comes Boyle, who discovered Boyle's Law. The face on the right, of course, is the famous Taylor FULSCOPE Controller. It is found in practically every process industry.

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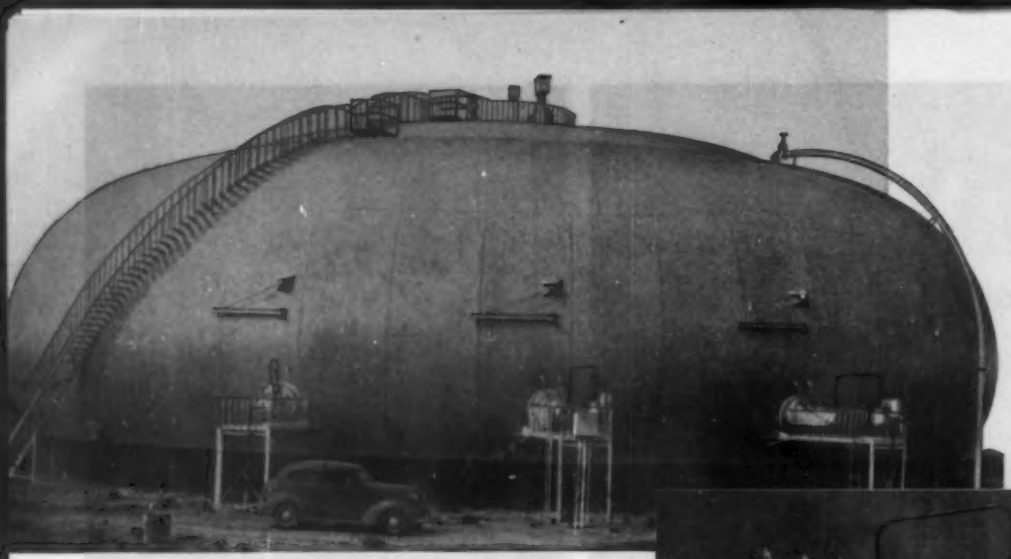

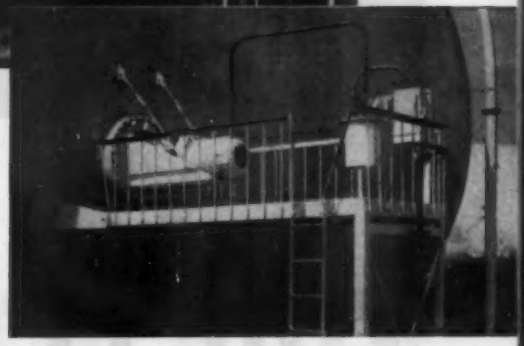

ONLY 75 HP NEEDED TO BLEND THIS TANK

Three 25-horsepower *Lightnin Mixers* blend the contents of this 100,000-barrel tank in less than two hours.

Purchased for obvious savings over recirculating pumps, the mixers cost approximately $5,000. They eliminate the need for swing lines and piping that, by themselves, would have cost more than this.

Lightnin Mixers fit old tanks as well as new ones. Existing manways may be used. *Lightnin Mixers* can be repacked from outside the tank, while it is under a full head of liquid.

Many *Lightnin Mixers* have been on the job 20 years and more. There is a wide range of models and sizes—all ruggedly built of standard interchangeable components to simplify upkeep. Every *Lightnin* is factory aligned, and guaranteed to do the job you want it to do.

Write for complete information, or check and mail the coupon for descriptive literature.

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LIGHTNIN PORTABLE MIXERS
World's largest-selling line. Electric or air motor, direct or gear drive. Sizes ⅙ to 3 HP.

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For tanks up to 5 million gallons. Gear motor or V-belt drive; motorless types. Sizes 1 to 25 HP.

LIGHTNIN TOP ENTERING AGITATORS
Turbine, propeller and paddle types. For open or closed tanks. 16 speeds available at gear heavy duty drive. Sizes ⅙ to 300 HP.

A COMPLETE LINE . . . UNEXCELLED TECHNOLOGY

cents a gallon cheaper for oil, or 2.1 cents a gallon cheaper for coal, depending upon whether the cost estimates of the National Petroleum Council's synthetic liquids committee or the Bureau of Mines are used. The former estimate was made after 16 months of study by 12 industry experts, while the amount of study which went into the latter is not known.

Chapman, who has deemed it necessary to have a coal hydrogenation plant of 30,000 barrels daily capacity in operation by 1955, has been opposed by other sources than the NPC report, which estimated the cost of catalytic gasoline from coal as 41.4 to 43.5 cents a gallon. Top officials of the Petroleum Administration for Defense, as well as Bureau of Mines personnel, have cited strong arguments that defense demands do not justify the need for liquids from coal now or within the next 10 years at least. Pointing to the unsuccessful attempts of numerous privately-financed oil companies to find an economical method of coal hydrogenation, top industry officials have repeatedly promised that when economics justified such a venture, private capital would be ready, willing and able to produce synthetic liquids in volume.

In fitting coal into the liquid fuels picture, industry spokesmen have cited the following considerations which make the Chapman project undesirable:

1) There is no shortage of petroleum now or in the foreseeable future; but should it become necessary to provide extra liquid fuels, the first step would be to substitute coal "as is" for residual fuel and upgrade residual into lighter liquids such as gasoline. Such a process is considered economically feasible and it is also believed that a major portion of the present 1.5 million barrel daily residual consumption could be transferred to coal, should it be necessary for national defense.

2) The needed chemicals that the proposed hydrogenation process is designed to produce can, and are, being produced from petroleum at less than present commercial prices for these chemicals.

3) Production of synthetic liquid fuels from oil shale should be economically justified long before a similar situation can exist for utilizing coal as a raw material, since the oil shale itself has no other value.

The Good Old Days

RIVALING THE weather as a topic for locker room gossip, inflation has become a subject on which everyone is an authority. If you are one to recall the "good old days" when you could buy a wheelbarrow full of groceries for a dollar, your morale might be boosted by a look at the gasoline picture.

Under the auspices of the Oil Information Industry Committee, a road test program with actual cars and representative gasolines showed that two gallons of today's gasoline do the same amount of useful work which required three gallons in the 1920's. To measure the quarter-century improvement in gasoline value, engineers duplicated the conditions that prevailed in the oil and automotive industries in the mid 20's. The resulting specially prepared fuels and reconditioned automobiles—typical of that era—were then compared with present day gasoline and engines. The tests gave ample proof of the cumulative gains in power output and fuel economy prevailing in 1950 and 1951 as compared with the state of progress that existed in 1925 and 1926.

In a typical acceleration test, where both cars were accelerated for a period of 20 seconds using the gasoline of their respective eras, the 1928 car covered a distance of 1060 feet, while the 1951 car covered 1600 feet. Although the 1951 model weighed nearly 1000 pounds more, it nevertheless showed a 51 percent better accelerating ability than its 1928 namesake.

In the fuel economy run, it was the same story. The old car logged a respectable 15.25 miles per gallon, but the new model delivered 18.98 miles to the gallon.

Freedom and the Oil Industry

THE ONLY shortages which bother the oil industry are in the materials it needs for expansion, not in the products it has to sell. At the same time, the petroleum industry cannot meet tremendously increasing civilian and military demands for its products without private initiative and the profit motive. This was the recent message of Dr. Robert E. Wilson, Chairman of the Board of Directors of the Standard Oil Company (Indiana).

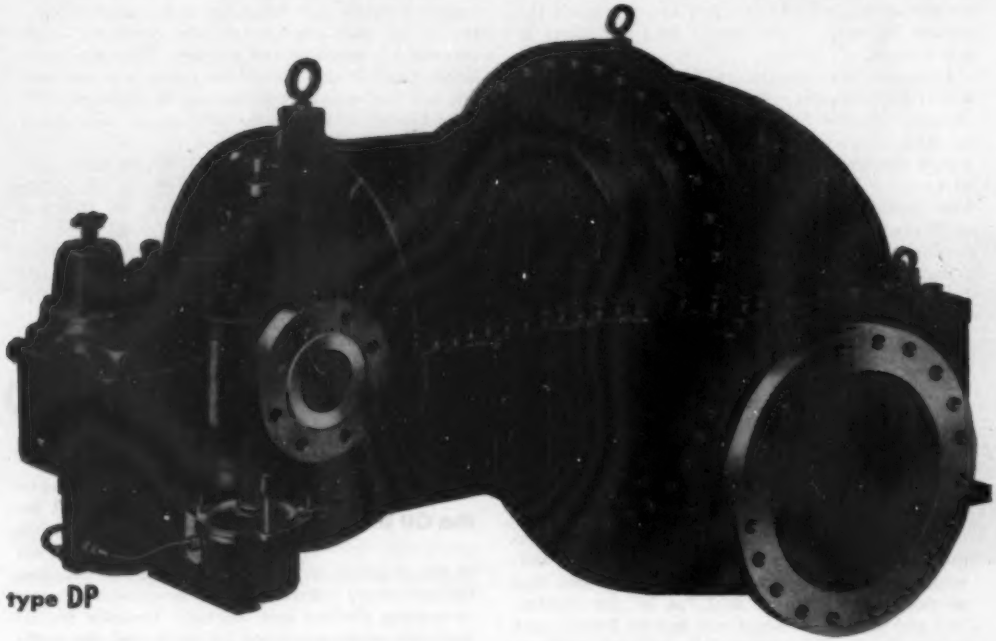
Dr. Wilson's address carried a warning that freedom of American business is in serious danger from a governmental interference which would be against the public interest. He said that unless the oil industry is free to manage its own business without undue interference from bureaucrats, oil's service to the people "will surely wither."

Going into considerable detail to substantiate his points, Dr. Wilson called attention to the fact that it is much easier to buy gasoline today than it is to buy a postage stamp or a soda. He also cited facts to show that gasoline is still a bargain, in spite of excessive taxes; prices for oil products are determined by vigorous competition, and oil industry profits are fair—lower than most people think.

"There is one guarantee we must have if the progress of the people through petroleum is to continue," Dr. Wilson said in conclusion. "That one thing is freedom—freedom to explore where we will, freedom to conduct our research, freedom to seek capital and build plants and facilities, freedom to earn profits with which to finance expansion and maintain our credit."

General Electric Announces

A NEW ADVANCE IN



type DP

Custom Performance from Standard Turbine Drives now possible through new Designs and Manufacturing Methods

Now you can select the mechanical-drive turbine that will give you maximum mechanical power for your fuel dollar . . . and without the delay and expense of special engineering. General Electric's four new multi-stage drives are *standards,* designed to meet your *specific* requirements.

Four new governing systems give you a wide selection of performance ratings. A new sectional valve gives you greater efficiency for part load operation. Many other improvements make these the finest turbines of their size General Electric has ever produced.

Secret of their adaptability is in the method of manufacture. By using interchangeable casting patterns, designed to be combined in a variety of ways, it's possible for the factory to "customize" standard machines for individual applications. You get a better turbine, designed for your job, and the delivery time is shorter, the cost lower.

Get the full particulars on these new multi-stage turbine drives. Write for our new bulletin, GEA-5580, "G-E Multi-Stage Turbine Drives." General Electric Company, Section 252-53, Schenectady, N. Y.

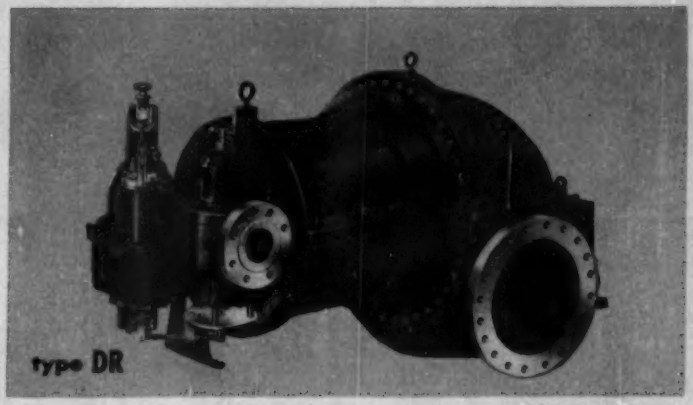
GENERAL ELECTRIC

252-53

MULTI-STAGE TURBINE DRIVES

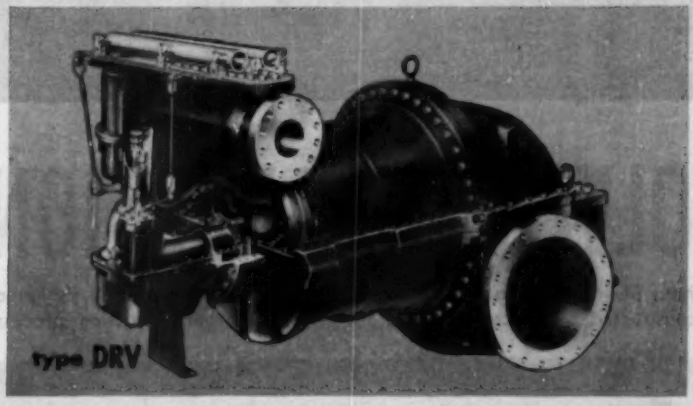
type DP

Dependable power over a 30 per cent adjustable speed range.



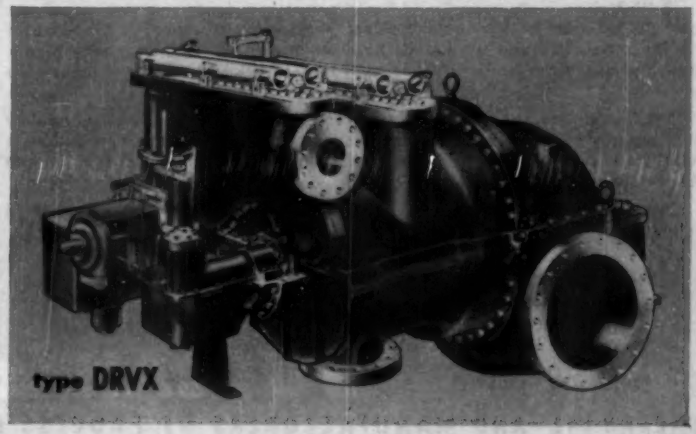
type DR

Oil-relay governor makes possible a speed range of 6 to 1, with only 4 per cent regulation and ½ per cent steady state speed variation.



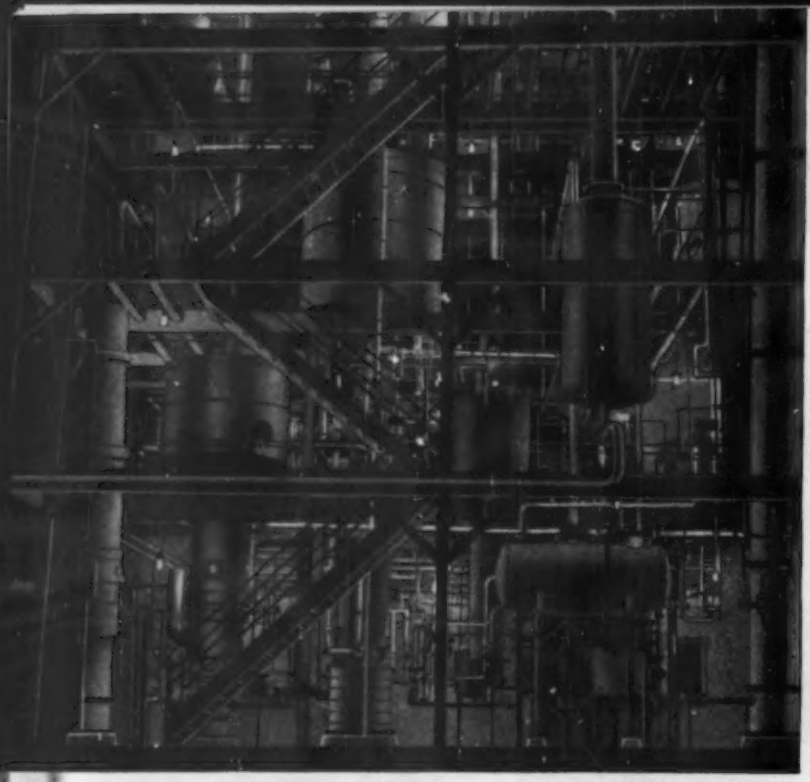
type DRV

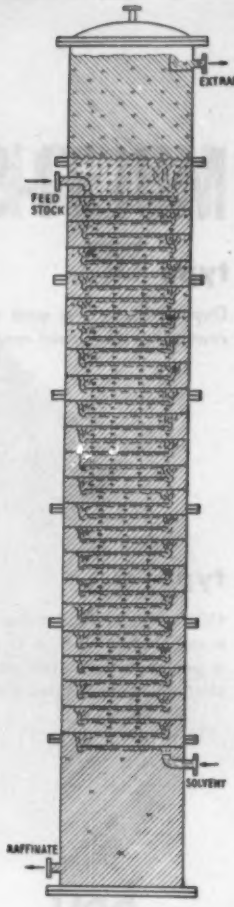
Automatic sectional valves linked to the oil-relay governor minimize throttling losses under fluctuating load factors, make possible substantial operating savings.



type DRVX

For applications where process steam is desired at a definite, steady pressure. Extracted steam pressure remains constant even when load on the unit fluctuates and the flow of extracted steam varies.





Diagrammatic sketch of liquid-liquid extraction column.

SOLVENT EXTRACTION

The photo above shows a complete wood rosin purification plant designed and constructed by Vulcan, utilizing the Vulcan solvent extraction process.

THE Vulcan baffle-type liquid-liquid extractor consists of a vertical column packed with a series of horizontal baffles. The turbulent region at the edge of each baffle serves to remix the liquids between stages. Either phase may be the continuous phase. Each baffle is made horizontal and flat by the use of adjustable spacer posts.

This equipment has been highly successful in the organic chemical industry and it is equally suitable for hydrocarbon separations. Each new application is carefully checked in the Vulcan laboratories to assure economical design and to permit performance guarantees.

These extractors are available in all corrosion resistant materials and in diameters to ten feet.

The Vulcan organization is at your service to provide:

- Technical and economic surveys
- Research and development
- Process and mechanical design
- Equipment manufacture
- Plant erection and startup

50th Anniversary 1901 1951

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PAD FORECASTS:

4.4 Percent Demand Hike in 1952

ROBERT E. SPANN, Eastern Editor

TOTAL demand for U. S. petroleum in 1952 will average 7,775,000 barrels daily, an increase of 330,000 barrels, or 4.4 percent, over the anticipated requirements for 1951, according to a forecast of the program division of Petroleum Administration for Defense.

The daily average anticipated demand for 1952 is the same as was forecasted by the economics committee of the Independent Petroleum Association of America earlier.

These estimates represent the smallest year-to-year increase in demand since 1949, when total requirements for that year fell below the preceding 12-month period. PAD's forecast of full 1951 demand places the total at 642,000 barrels a day over 1950 and requirements in the latter year were 683,000 barrels daily higher than in 1949.

The anticipated tapering-off in the rate of increase, according to PAD, is the result of several influences:

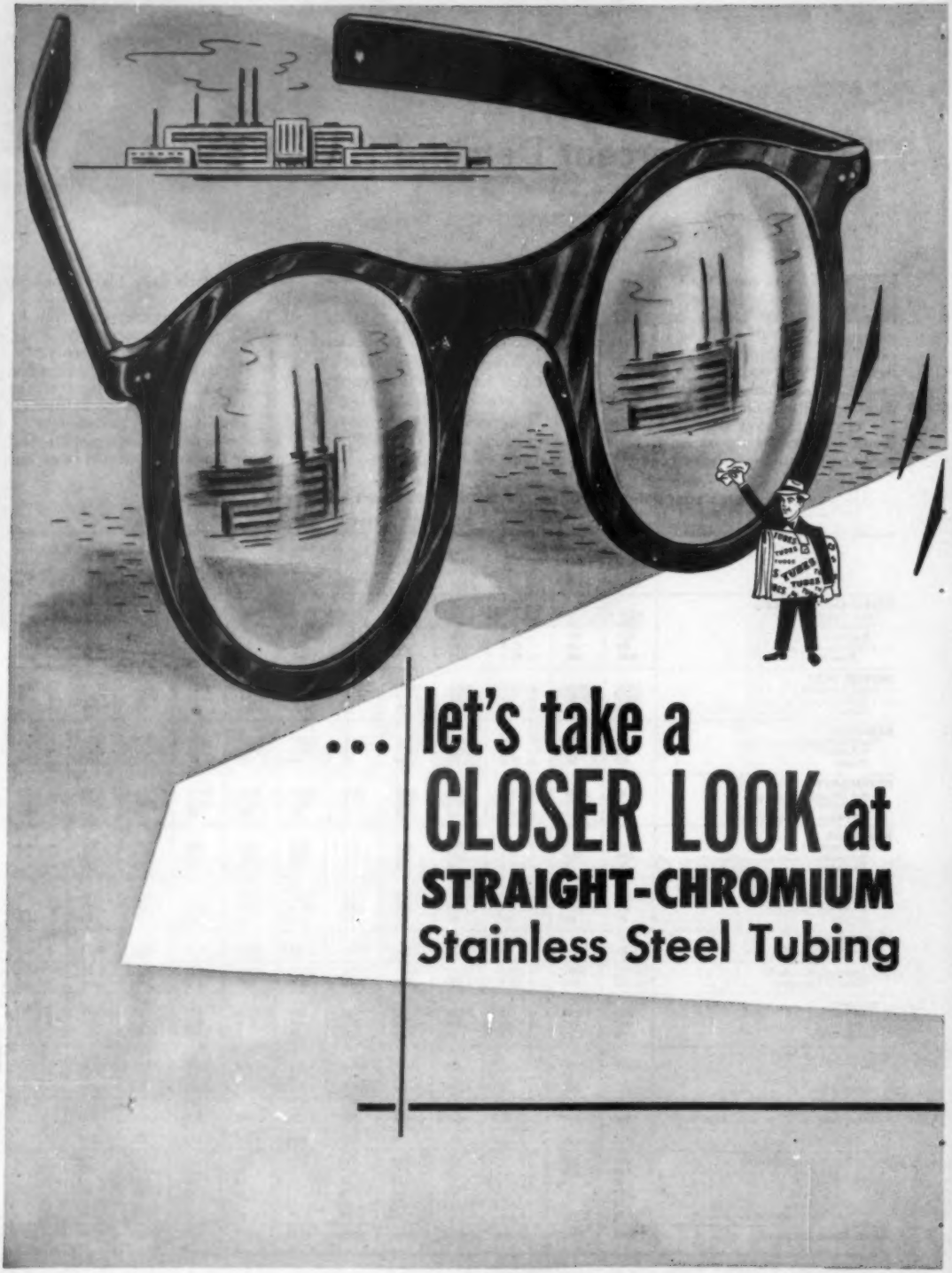
- The level of business activity has already received most of the stimulation from the defense effort that can be expected.
- Production of automobiles and oil burners is expected to decline

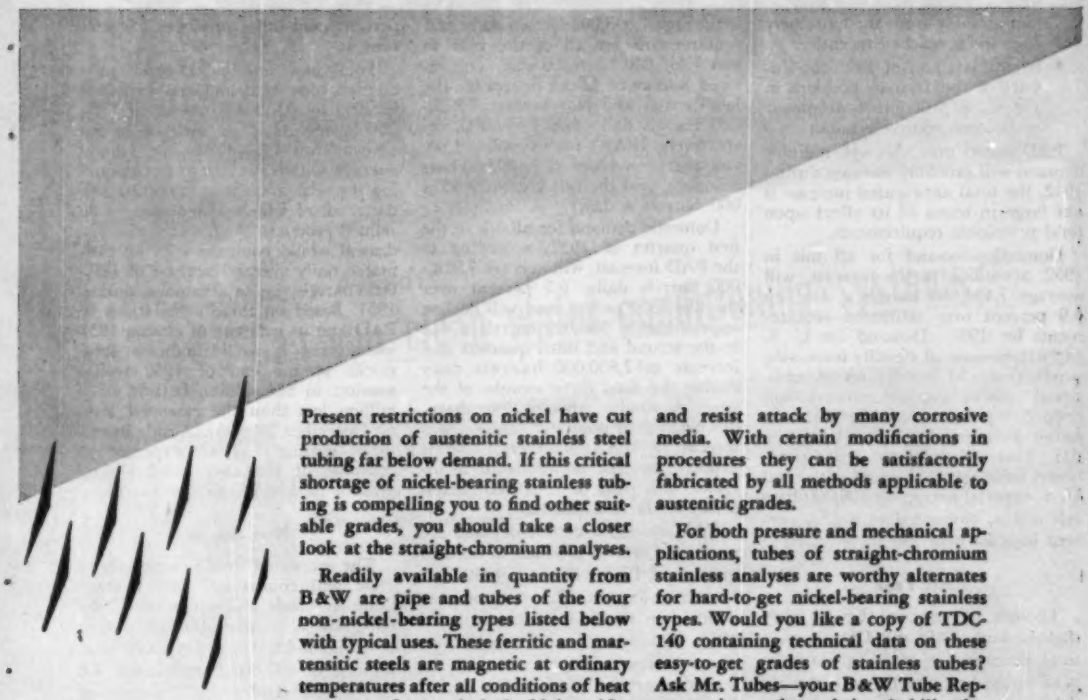
Petroleum Administration for Defense Forecast of Supply and Demand

(Thousands of Barrels Daily Average)

	FIRST QUARTER		Percent Change '52-'51 1st Qtr.	SECOND QUARTER		THIRD QUARTER		FOURTH QUARTER		Year 1952	Year 1951	Percent Change '52-'51 Full Year
	1952	1951		1952	1951	1952	1951	1952	1951			
DEMAND—ALL OILS												
Total Demand	8328	7737	+ 7.6	7438	7082	7209	7129	8046	7853	7775	7445	+ 4.4
Domestic	7928	7446	+ 6.5	7038	6655	7009	6818	7830	7439	7454	7039	+ 5.9
Export	400	291	+ 37.5	400	407	250	511	215	414	321	406	— 20.9
Crude Oil	60	89	— 32.6	60	85	60	70	40	61	60	76	— 21.1
Products	340	202	+ 68.3	340	322	190	441	175	353	261	330	— 20.9
MOTOR FUEL												
Total Demand	3029	2732	+ 10.9	3463	3210	3480	3336	3234	3124	3302	3100	+ 6.5
Domestic	2934	2668	+ 9.9	3367	3117	3425	3193	3184	2983	3228	2991	+ 7.9
Export	95	64	+ 48.4	95	93	55	135	50	141	74	109	— 32.1
RESIDUAL												
Total Demand	1811	1826	— 0.8	1493	1543	1364	1409	1724	1719	1602	1633	— 1.3
Domestic	1751	1788	— 2.0	1423	1463	1344	1310	1684	1654	1550	1552	— 0.1
Export	60	38	+ 57.9	70	80	40	90	40	65	52	80	— 34.6
DISTILLATE												
Total Demand	1920	1724	+ 11.4	1052	956	946	942	1594	1513	1376	1283	+ 7.2
Domestic	1835	1693	+ 8.3	972	900	916	847	1579	1453	1321	1223	+ 8.0
Export	85	31	+174.3	80	56	30	95	25	61	55	60	— 8.3
KEROSINE												
Total Demand	520	474	+ 11.8	365	238	219	239	462	455	368	351	+ 4.8
Domestic	490	469	+ 6.4	235	220	214	202	457	233	348	331	+ 5.1
Export	30	5	+500.0	30	16	5	37	5	22	17	20	— 15.0
OTHER PRODUCTS												
Total Demand	934	885	+ 5.5	1081	1022	1125	1098	986	931	1023	984	+ 3.9
Domestic	867	821	+ 5.6	996	945	1055	1014	911	867	960	912	+ 5.3
Export	70	64	+ 9.4	85	77	60	84	55	64	63	72	— 13.9
NEW SUPPLY												
Total New Supply	7851	7454	+ 5.1	7702	7360	7564	7534	7933	7756	7763	7574	+ 2.5
Domestic Crude Oil	6321	5964	+ 5.7	6297	6142	6174	6212	6368	6273	6290	6140	+ 2.3
Natural Gasoline	580	564	+ 2.8	580	542	570	542	590	573	575	555	+ 3.6
Imports												
Crude Oil	500	484	+ 3.3	520	530	530	531	540	530	520	519	+ 0.2
Residual	430	410	+ 4.9	300	216	275	218	400	350	348	323	+ 7.7
Other Oils	30	32	— 6.3	25	30	25	21	35	30	29	28	+ 3.6
STOCK CHANGES												
Total, All Oils	—477	—283	.....	+264	+496	+306	+395	—152	—97	—13	+120	.....
Crude Oil	.....	—162	.....	.....	+156	.....	+ 78	.....	.....	.....	+ 19	.....
Products	—477	—121	.....	+264	+340	+306	+317	—152	—97	—13	+110	.....
CLOSING STOCKS												
Total, All Oils	566	557	.....	610	602	636	636	624	639	624	639	.....
Crude Oil	255	234	.....	255	248	255	255	255	255	255	255	.. ..
Total, All Products	331	323	.....	355	354	383	383	369	374	369	374	.....
Gasoline	145	142	.....	131	126	115	112	120	123	126	123	.....
Residual	40	38	.....	41	42	51	48	48	48	48	48	.....
Distillate	44	43	.....	60	68	93	97	84	88	84	88	.....
Kerosine	15	14	.....	25	24	31	34	24	27	24	27	.....
Other Products	87	85	.....	89	92	93	92	87	88	87	88	.....
Crude Runs Required	6091	6492	+ 3.1	6667	6394	6564	6531	6778	6667	6660	6522	+ 2.4

* Stock figures in millions of barrels.


... let's take a
CLOSER LOOK at
STRAIGHT-CHROMIUM
Stainless Steel Tubing



Present restrictions on nickel have cut production of austenitic stainless steel tubing far below demand. If this critical shortage of nickel-bearing stainless tubing is compelling you to find other suitable grades, you should take a closer look at the straight-chromium analyses.

Readily available in quantity from B&W are pipe and tubes of the four non-nickel-bearing types listed below with typical uses. These ferritic and martensitic steels are magnetic at ordinary temperatures after all conditions of heat treatment, have relatively high oxidation resistance at elevated temperatures, and resist attack by many corrosive media. With certain modifications in procedures they can be satisfactorily fabricated by all methods applicable to austenitic grades.

For both pressure and mechanical applications, tubes of straight-chromium stainless analyses are worthy alternates for hard-to-get nickel-bearing stainless types. Would you like a copy of TDC-140 containing technical data on these easy-to-get grades of stainless tubes? Ask Mr. Tubes—your B&W Tube Representative — about their suitability for your applications.

APPLICATIONS

B&W Croloy 12 A1 (Type 405, Seamless) Non-hardening—does not undergo appreciable transformation; therefore no sudden volume change occurs during heating—corrosion and oxidation resistant. Typical uses: Conveyor lines in oil refining and chemical processing, heat exchanger tubing, boiler tubing in mercury heat cycle, catalytic oil cracking processes where fins have been welded to tubes.

B&W Croloy 12 (Type 410, Seamless and Welded) Hardenable—moderate corrosion and heat resistance. Typical uses: Machinery in the chemical and food processing and packaging fields.

B&W Croloy 18 (Type 430, Seamless and Welded) Sufficient ductility for forming simple parts—good corrosion and oxidation resistance—can be polished or buffed to pleasing finish. Typical uses: Conveyor lines in chemical processing field; condensers and piping in production, transportation, and storage of nitric acid and in nitrating operations involving mixed acids; furnace parts; retorts; ornamental structures.

B&W Croloy 27 (Type 446, Seamless) Corrosion resistant—excellent heat resisting qualities. Typical uses: Furnace parts, heat interchangers, kilns, pyrometer protection tubes, soot blower elements, dehydrogenation equipment in chemical and oil refining fields. Also well suited for glass sealing applications.

THE BABCOCK & WILCOX TUBE COMPANY

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B&W SEAMLESS and WELDED TUBES

TA-14518

considerably from the extremely high levels reached recently.

- By the last half of 1952 the impact of the Iranian problem in the U. S. will either disappear or become relatively minor.

PAD stated that although military demand will probably increase during 1952, the total anticipated increase is not large in terms of its effect upon total petroleum requirements.

Domestic demand for all oils in 1952, according to the forecast, will average 7,454,000 barrels a day, up 5.9 percent over estimated requirements for 1951. Demand for U. S. exports, because of steadily increasing production and installation of additional refining capacity abroad, will drop 20.9 percent from the 1951 rate to an average of 321,000 barrels a day. This will represent a sharp reversal from the 1951 trend with total U. S. exports, averaging 406,000 barrels a day, amounted to a 33.6 percent increase over 1950.

Early Peak

Though the actual figures vary slightly, both PAD and IPAA expect total demand for 1952 to reach its peak in the first quarter with the anticipation that exports will drop sharply and some decrease will occur in domestic requirements during the latter part of the year. Previously, total demand has been the greatest in the final three months of the year due to the seasonal expansion in distillate and residual fuel oil requirements.

PAD forecasts domestic and export demand in the first three months of 1952 will average 8,328,000 barrels a day, or 7.6 percent above actual requirements in the like 1951 period. IPAA's forecast for the first quarter placed total demand at 8,170,000 barrels daily, which would be 5.5 percent over the 1951 first three months. These estimates compare with the Bureau of Mines forecast of daily average demand of 8,140,000 barrels for the first 1952 quarter, or an increase of 5.2 percent over the like 1951 period. (See WORLD OIL, November, 1951).

While PAD's forecast for the first three months of 1952 is higher than the expectations of IPAA and Bureau of Mines, its estimate of total demand for the last quarter and the daily average for all of 1951 is below the other two. PAD estimates total demand in the last three months of 1951 to average 7,853,000 barrels daily and requirements for all of the year to run 7,445,000 barrels a day. The revised Bureau of Mines figures for the last quarter and year average 7,913,000 barrels daily and 7,452,000, respectively. IPAA's forecast placed the last quarter average at 7,880,000 barrels daily and the full year at 7,465,000 barrels a day.

Domestic demand for all oils in the first quarter of 1952, according to the PAD forecast, will average 7,928,000 barrels daily, 6.5 percent over the like 1951 period, and will decline approximately 900,000 barrels a day in the second and third quarters and increase to 7,850,000 barrels daily during the final three months of the year. A similar, though less sharp, down-trend in domestic demand was forecast by IPAA; however, the latter expects domestic requirements to increase to a peak of 7,910,000 barrels a day in the last quarter.

PAD estimates export demand for crude and refined products in the first quarter of 1952 will average 400,000 barrels a day, or 37.5 percent over demand in the first three months of 1951. This rate of total export shipments is expected to continue into the second quarter, though in that period it will be below the rate of the 1951 second quarter, and to drop sharply in the second half of 1952, averaging no more than 243,000 barrels daily in the final six months. This trend also was anticipated in the IPAA forecast, though the latter estimated total exports for all 1952 to average 314,000 barrels daily, or 6000 barrels a day less than expected by PAD.

While export shipments of all major refined products in 1951 have been at sharply higher rates than in the preceding year, PAD expects exports of all products in 1952 to average considerably less than in the current year.

Total demand, as well as domestic demand, for all refined products in 1952 except residual fuel oil, however, will show moderate increases over the estimated requirements of 1951, according to the PAD forecast. With export demand expected to be 24.6 percent lower and domestic requirements anticipated to be just slightly less than in 1951, total demand for residual fuel in 1952 is forecast at 1,602,000 barrels a day, or 1.3 percent under the 1951 estimate. Increases in various product demand expected, are: Gasoline, 6.5 percent; distillate, 7.2 percent kerosine, 4.8 percent; and other products, 3.9 percent.

Total new supply (domestic production plus total imports) expected in 1952 by PAD will average 7,762,000 barrels daily, an increase of 2.5 percent over 1951, indicating a daily average withdrawal from stocks during the year averaging 13,000 barrels daily, all of which is expected to be refined products. Such a rate of withdrawal would compare with an estimated daily average increase of 129,000 barrels in total stocks during 1951. Based on these calculations of PAD and its estimate of closing 1951 inventories, it would indicate total stocks at the end of 1952 would amount to 624 million barrels, or 5 million less than the expected level on December 31, 1951. Crude inventories during 1952 are expected to continue at the anticipated closing level of 1951 of 255 million barrels.

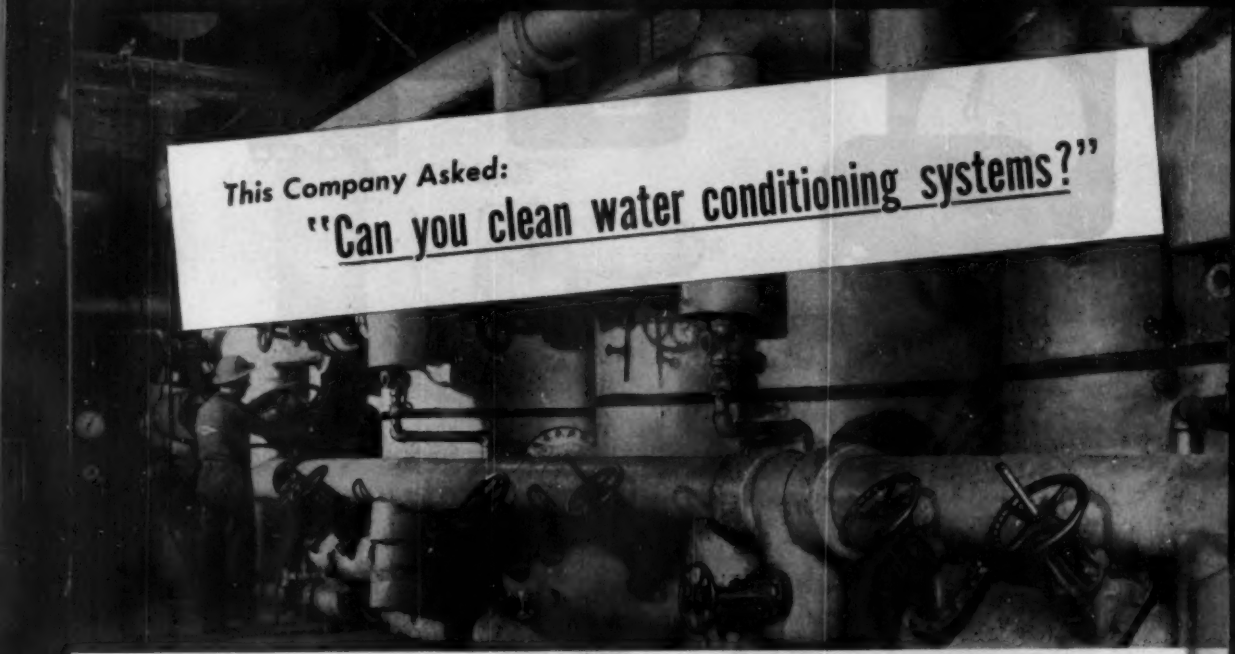
New Supply

The estimated total new supply in 1952 will consist of daily average domestic crude production of 6,290,000 barrels, natural gasoline output of 575,000 barrels a day, and total imports of 897,000 barrels daily. Of the latter, crude would consist of 520,000 barrels a day, approximately the level expected for all 1951. Product imports in 1952, however, are expected to rise to 377,000 barrels daily, compared with the estimated average of 351,000 barrels a day in 1951, indicating total 1952 imports will be 27,000 barrels a day higher than in 1951.

PAD's estimate of 1952 domestic crude production is 2.3 percent higher than the anticipated average for all of 1951, and consists of a daily average output of 6,321,000 barrels in the first quarter, 6,297,000 in the second, 6,174,000 in the third, and 6,368,000 in the fourth quarter. It will not be possible to increase domestic crude production much over a level of 6,353,000 barrels a day until additional pipe line capacity is provided, particularly in West Texas, according to PAD. The agency expects 300,000 barrels daily of West Texas-Gulf line capacity to be added in the third quarter and 70,000 barrels daily in the same period with completion of the Platte line from Wyoming to Wood River, Ill. The 209,000-barrel daily Rancho line from West Texas to Houston is expected to be completed in the fourth quarter of 1952, according to PAD.

DOWELL SERVICE

CHEMISTRY APPLIED TO MAINTENANCE CLEANING PROBLEMS



Dowell Service has cleaned many types of water supply equipment FAST!

If deposits are cutting production and profits in your plant . . . Dowell Service offers an effective remedy! For example, in water supply and water treating systems, deposits may accumulate in pipes, pumps and filters . . . impairing operating efficiency. Maintenance men in many industries rely on Dowell Service to clean operating equipment . . . *without dismantling and with a minimum of downtime!*

Experienced Dowell engineers do the job, using Dowell-designed, truck-mounted equipment. Liquid solvents designed to remove deposits quickly, efficiently and economically are applied according to the techniques demanded by the job: for example, by filling, spraying, jetting, cascading or vaporizing. Often equipment can be cleaned in operation.

Let Dowell Service *save you time and money* in your maintenance cleaning! Call the nearest Dowell office today for FREE consultation.

Recent Dowell jobs in Feedwater Systems

SCREEN FILTERS: In less than three hours, Dowell Service removed 90% of deposits from filters used to screen river water for a 48" strip mill.

WATER SOFTENER: Approximately 18 inches of hard calcium carbonate piled up in the bottom of a water softener's deaerating compartment. In less than one day, Dowell Service thoroughly cleaned compartment.

FILTER BEDS: The backwash rate on an anthracite filter was reduced to 75 gallons per minute by accumulated deposits. After Dowell Service, backwash rate was increased to an effective 335 gallons per minute.

ION EXCHANGE BEDS: Iron oxide clogged an ion exchange water softener. Before cleaning, two pumps were required to provide pressure for adequate back wash. After Dowell Service, one pump was sufficient.

FEEDWATER LINES: Before cleaning, it was necessary to use three 100 horsepower pumps to force water through clogged feedlines to a boiler house. Following Dowell Service, only one pump was required.

PUMP: Two high pressure feedwater pumps were nearly clogged with deposits. Dowell service completely cleaned them along with rest of the feedwater system.

WATER WELL: Before treatment, a water well produced only 108 gallons per minute with a 35' drawdown. After Dowell acidizing, water flow increased to 450 gallons per minute with a 27' drawdown.

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★ *Maintenance cleaning service for industrial heat exchange equipment.*
★ *Chemical services for oil, gas and water wells.*
★ *Magnesium anodes for corrosion control.*

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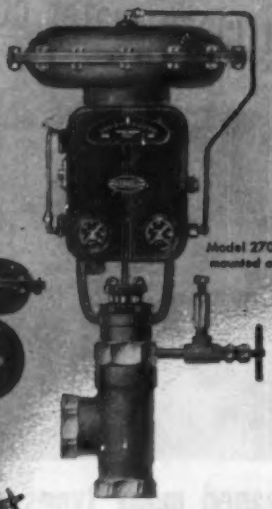
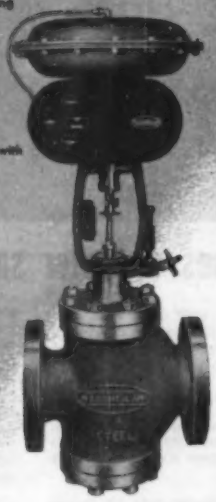
THE DOW CHEMICAL COMPANY

Indicating, non-indicating and recording pressure or temperature controllers.

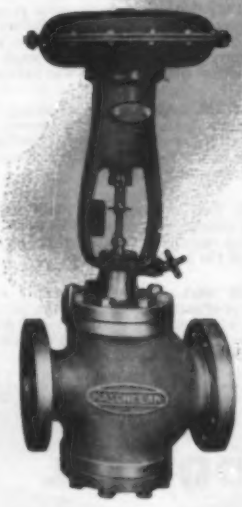
12000 Series Liquid Level Controller.



Model 2707 Pressure Controller mounted on control valve.



10000 Series Control Valve with Series 7400 Positioner.



10000 Series Control Valve.

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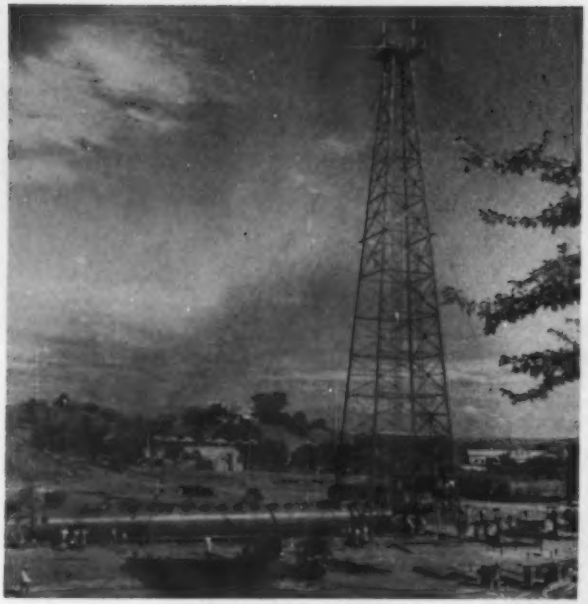
New York 6; Atlanta; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Dallas 2; Philadelphia 25; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Co. of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Toronto, Canada (Canada Metal Company, Limited)



LOOKING FORWARD to the day when internal conditions in Burma will permit greater distribution of locally refined products, Burmah Oil Company prepares to raise an atmospheric column at its refinery near Chouk. A complete two-stage distillation unit, with provision for wax extraction, is in process of erection as part of the general expansion program at the refinery.

News Notes on Refinery and Other Plant Construction

***Petroleum Refiner's* Next "Box Score"**

Tabulation Will Appear in the January Issue

Shell Increasing Capacity At Norco, La., Refinery

Addition of a catalytic cracking plant at Shell Oil Company's Norco, La., refinery is expected to make the Norco plant independent of Shell's Houston plant in production of aviation gasoline. Recent discoveries of new sources of crude oil in Louisiana has insured the future of the Norco installation in the Shell program.

Crude distillation will be increased along with expansion of the alkylation plant and additional storage facilities will be provided. This $30 million expansion is only one part of Shell's nation-wide program that will cost $100 million and add 4 million gallons daily to the company's national output.

Standard (Ohio) Starts Three Expansion Units

Chromia-alumina will be used as a catalyst for catalytic reforming for the first time when Standard Oil (Ohio) incorporates the new development into its reforming expansion program at Lima, Ohio. Engineering and design work will be started at once on the $8.5 million unit, and at the same time a $2.4 million program to expand the crude coking unit will be started.

At Toledo, Standard Oil (Ohio) plans to begin construction early next year on a new 13 million sulfuric acid alkylation unit for which certificates of necessity have already been granted. This unit will double the present capacity by about 2000 barrels daily of alkylate. Completion is scheduled in 15 months.

Kellogg Starts Engineering On Chile's First Refinery

Engineering work is underway on Chile's initial refinery which is being constructed for Empresa Nacional de Petroleo near Valparaiso. In about one year the M. W. Kellogg Company expects to begin actual construction on the $10 million program which will give Chile 20,000 barrels a day of refining capacity. Processing facilities will include crude oil distillation, vis-breaking, thermal reforming, gasoline stabilization and treating equipment for sulfur removal from fuel gas, LP gases, motor gasoline, etc. Production will be moved to marketing points by pipe line and truck.

2000 Barrels Avgas Added In Texas City Expansion

Pan American Refining Corporation has announced a $18 million expansion program at Texas City which will increase the crude capacity of the refinery by 12,000 barrels per day. In addition, the new facilities will increase the production capacity of military grade aviation gasoline by 2000 barrels daily.

As part of the program a 30,000-barrel-per-day Fluid catalytic cracking unit will be added, as will auxiliary equipment, including a polymerization unit. The existing combination crude and thermal cracking units will be revamped to increase capacity. As yet activity is in the planning stage and Pan American officials will not hazard an estimate as to completion date because of the uncertainty regarding the delivery of materials.

El Dorado Refinery Gets Polybutene, Propylene Units

Polybutene production in the U. S. will be increased by approximately 47,619 barrels annually when a new unit authorized by Pan-Am Southern Corporation for its El Dorado, Ark., refinery is completed. A second new unit will produce about 90,476 barrels yearly of propylene tetramer.

The polybutene unit is scheduled for completion in February, 1952, while the propylene tetramer unit is being readied by revamping the present polymerization unit so that it can be switched from high grade "poly" gasoline manufacture to tetramer production as the market fluctuates.

Standard-Vacuum Agreement With India Not Disclosed

Negotiations between Standard-Vacuum and the government of India probably have reached an advanced stage, while the Burmah Oil Company and Caltex companies are still interested in the possibilities of building and operating Indian refineries.

Standard-Vacuum has offered to build one of the three $30 million refineries near Bombay. India reportedly has promised not to nationalize her oil resources for 30 years and to pay compensation if she takes over after that time.

Roosevelt O & R to Build Benzene Extraction Plant

Plans for the construction of a new $2 million unit for benzene and toluene extraction from crude oil and other charge stocks utilizing the new platforming process have been announced by Roosevelt Oil & Refining Corporation at Mount Pleasant, Mich. The process is licensed by Universal Oil Products Company of Chicago, and

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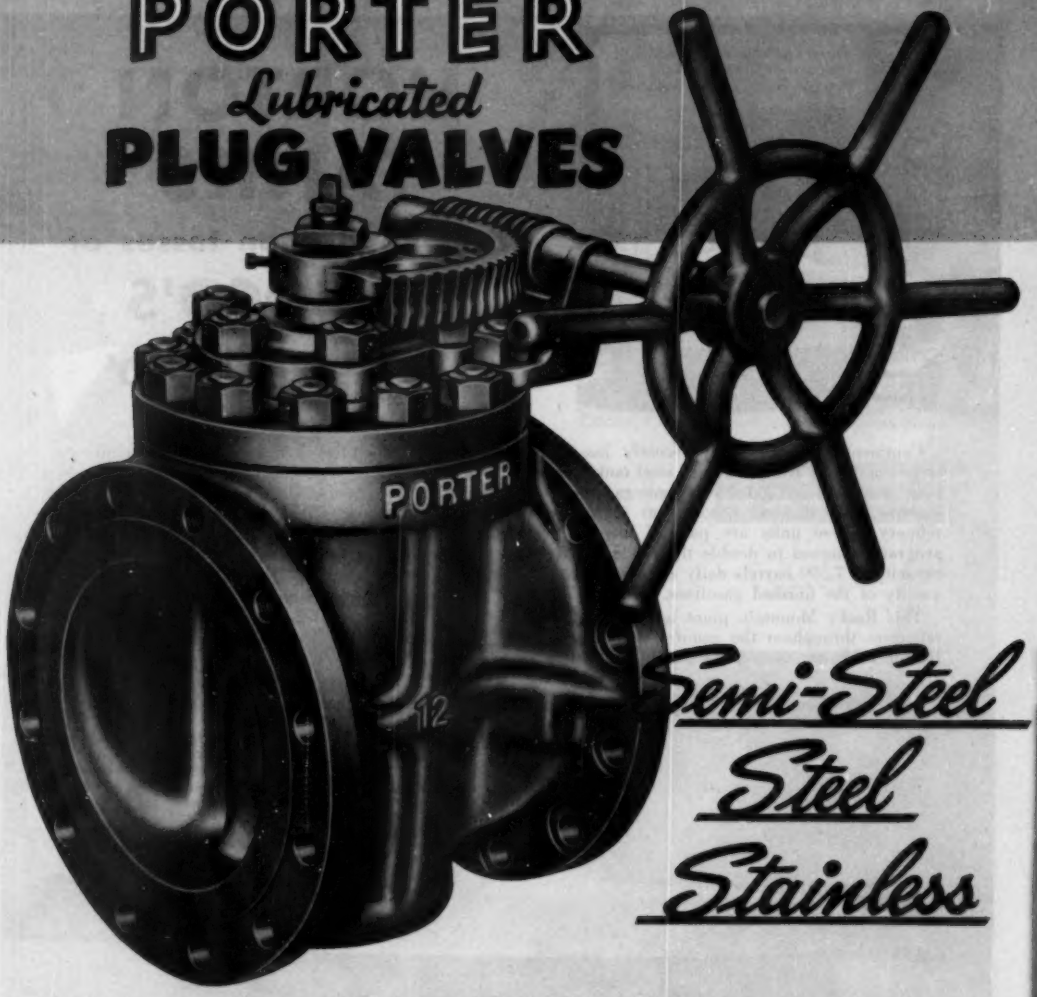

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DRAWER 2650 TULSA 1, OKLAHOMA

Three umbrella roof tanks built for Continental Oil Company's refinery located at Denver, Colorado.

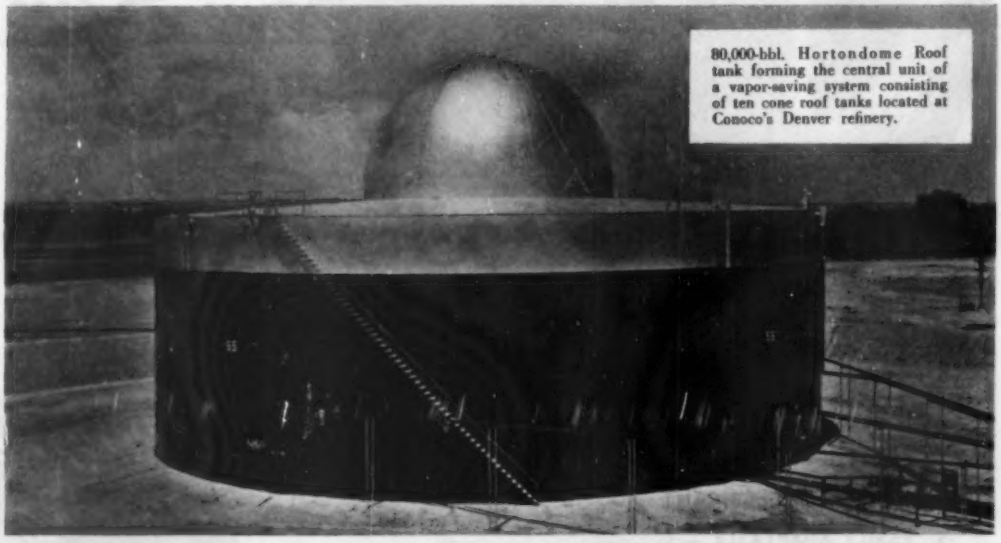
HORTON TANKS

cut evaporation losses at CONOCO'S Denver Refinery

Continental Oil Company recently installed a large number of Horton welded steel tanks to store base gasoline, Ethyl gasoline, N-tane gasoline, poly gasoline, and demand gasoline at their Denver refinery. These units are part of an expansion program designed to double the crude processing capacity to 7,500 barrels daily and to improve the quality of the finished gasolines.

This Rocky Mountain plant is typical of many refineries throughout the country that depend on Horton tanks to store crude oil and refined products. The complete line of efficient structures—Hortonspheres, Hortonspheroids, Hemispheroids, Hortondome Roofs, Horton Floating Roofs and cone roof tanks—has been carefully designed to reduce evaporation losses by utilizing modern storage principles.

If you are interested in obtaining the many inherent advantages of modern storage facilities for your refinery, tank farm, or pipe line station, write our nearest office. There is no obligation on your part.



80,000-bbl. Hortondome Roof tank forming the central unit of a vapor-saving system consisting of ten cone roof tanks located at Conoco's Denver refinery.

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

Atlanta 3 ..... 2146 Healey Building	Detroit 26 ..... 1520 Lafayette Building	Salt Lake City 4 ..... 531 West 17th South Street
Birmingham 1 ..... 1548 North Fiftieth Street	Houston 2 ..... 2126 C & I Life Building	San Francisco 4 ..... 1551—200 Bush Street
Boston 10 ..... 1030—201 Devonshire Street	Los Angeles 17 .. 1534 General Petroleum Building	Seattle 1 ..... 1331 Henry Building
Chicago 4 ..... 2463 McCormick Building	New York 6 ..... 3302—165 Broadway Building	Tulsa 3 ..... 1626 Hunt Building
Cleveland 15 ..... 2234 Guildhall Building	Philadelphia 3 . 1608—1700 Walnut Street Building	Washington 6, D. C. ..... 1128 Cafritz Building

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Sociedade Chibridge de Construcoes Ltda., Av. Franklin Roosevelt, 194-S/704-C, Rio de Janeiro, Brazil
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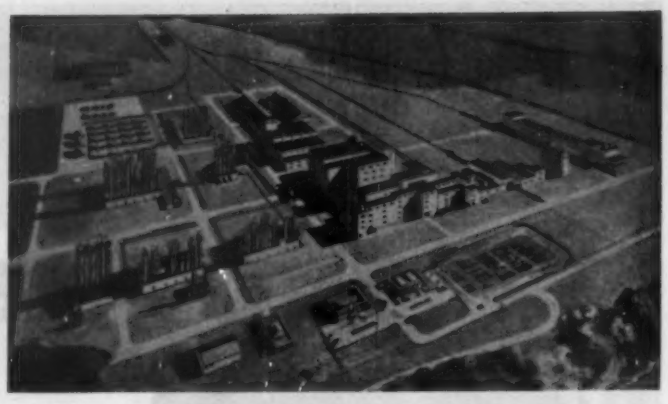
erection will be handled by Procon, Inc.

Final design of the units is now being completed, with field construction under way. Scheduled for completion in late summer, 1952, production is estimated at 71,000 barrels of benzene and 77,000 barrels of toluene annually.

Sinclair Begins Latest Houston Expansion Program

Engineering on the expansion program for Sinclair Refining Company at its Houston plant has been completed and construction contracts have been given to Fluor Corporation and C. F. Braun, major contractors for the project. The J. G. White Engineering Corporation will also do some of the work. The $28 million project will increase capacity from 85,000 to 110,000 barrels a day of crude.

Production of avgas and butylene will be increased by 100 percent and production of special Navy fuel and gasoline will be increased considerably.



AN ARTIST'S SKETCH of the petrochemical and textile fiber plant now being constructed at Edmonton, Alberta, by the Canadian Chemical Company, Ltd., gives a preview of what the completed plant will look like. The company, an affiliate of Celanese Corporation of America, hopes to complete construction by next winter. The plant will produce petroleum chemicals, cellulose acetate, acetate filament yarn and acetate staple fiber. It is anticipated production will meet Canadian chemical market demand, with production of some items in sufficient quantity for export.

Refining Projects Certified by PAD In November Aggregate $225 Million

A lengthy list of construction projects within the refining field was approved by the Defense Production Administration last month. The total cost for the projects listed below totaled over $255 million. The following list gives company name, site of construction, cost of project, percent at which project was certified for tax amortization, and general classification of production.

Allied Chemical & Dye Corporation, East St. Louis, Ill., $1,627,000, 70 percent, sulfuric acid. Atlantic Refining Company, Philadelphia, $3,214 million, 70 percent, sulfuric acid.

Cities Service Oil Company, Bartlesville, Okla., $12,310,000, avgas expansion. Cities Service, near Blackwell, Okla., $3,880,000, 65 percent, isobutane facilities. Cities Service, Lake Charles, La., facilities for hiking crude capacity 25,000 barrels daily for production of: 623 barrels LPG; 4430 barrels avgas; 6083 barrels kerosene and distillates; 420 barrels benzene; 1350 barrels toluene, etc. Expansion will include an additional crude oil distillation unit, enlargement of the catalytic cracking plants; new catalytic reforming unit; LPG recovery equipment; enlargement of the alkylation feed and acid recovery facilities. DPA certified $26,650,000 at 45 to 80 percents.

Coastal Oil Company, Port Newark, N. J., $275,000, 40 percent, storage capacity for military products. Consolidated Chemical Industries, Houston, $400,000, 70-15 precent, sulfur projects.

Deep Rock Oil Corporation, Cushing, Okla., $3,250,000, 65-90 percent, benzene and toluene. Detroit Chemical Works, Detroit, $950,000, 79 percent, sulfuric acid facilities.

Ethyl Corporation, Edgemoor, Del., $184,125, 90 percent, tetraethyl lead.

Ethyl Corporation, Baton Rouge, $4 million, 75 percent, tetraethyl lead.

General Petroleum Corporation, Torrance, Calif., approved at 90 percent for $528,000 and at 65 percent for $47,000 for avgas project. Globe Oil & Refining, Lemont, Ill., $3,894,053, basic products and avgas components. Great Southern Chemical Company, Corpus Christi, Texas, $4 million, chemical grade benzene and toluene. Gulf Oil, Port Arthur, Texas, $2,318,855, sulfuric acid.

Hancock Oil Company of California, Long Beach, $3 million, avgas production. Hugoton Plains Gas & Oil Company, Tyrone, Okla., $119,250, 90 percent, new production of 11,000 gallons daily of iso-butane. Humble Oil & Refining Company, Baytown, Texas, $110,000, 90 percent, avgas expansion. Second avgas project, $460,000, 90 percent.

Lion Oil, El Dorado, Ark., $67,558, sulfur. Magnolia Petroleum Company, Beaumont, Texas, basic products. Michigan Chemical Corporation, St. Louis, $81,681, 70 percent, sulfuric acid.

Ohio Oil Company, Robinson, Ill., $2,877,000, alkylates.

Pan American Refining Corporation, Texas City, $18,674,500, 2440 barrels avgas daily, motor grade gasoline, kerosene, and No. 2 fuel oil. Panoma Corporation, Carson County, Texas, $1,022,450, avgas project. Panoma Corporation, Texas County, Okla., $211,400, 90 percent, 7500 gallons daily iso-butane, and storage facilities.

Phillips Petroleum, Borger, Texas, $98,725, alkylates; Bartlesville, $25,865, alkylation expansion; Sweeney, Texas, facilities for production of large quantities of aromatics suitable for use in avgas production, as well as purified benzene and toluene for use by chemical industry. 4430 barrels avgas daily and 6083 barrels kerosene, $18,805,000, 15 to 90 percent; Ector County, Texas, $158,481, 40-65 percent natural gasoline project; Gray County, Texas, $409,612, 40 percent natural gasoline; Hutchinson County, Texas, $169,165, 65 percent, natural gasoline compressors; Moore County, Texas, $1,007,225, 65 percent, natural gasoline production; Crane, Texas, $510,200, 70 percent, elemental sulfur production; Lea County, N. Mex., $27,150, 65 percent, gasoline. Pontiac Refining Corporation, Corpus Christi, $2 million, avgas expansion.

Richfield Oil Corporation, Los Angeles, $43,107,000, 15-90 percent, 7700 barrels daily of avgas, benzene ethylene, all purpose gasoline. Rayonier, Inc., Powell Park County, Wyo., $1,314,000, 80 percent, elemental sulfur.

Shell Oil Company, Norco, La., $30 million, 15-90 percent, basic refining facilities, including crude distillation and catalytic cracking and additions to the alkylation unit. Crude capacity will be increased 25,000 barrels daily with an output of 11,960 barrels kerosene, 11,780 barrels motor gasoline, and 3620 barrels avgas daily. Shell Oil Company, Madison County, Ill., $42.5 million, basic refined products and avgas components.

Sinclair Refining Company, Hartford, Ill., $34,400, 15-90 percent, facilities for boosting crude capacity by 37,000 barrels daily and increasing product output as follows: motor gasoline, 16,325 barrels daily; fuel oils, 14,585 barrels daily; jet fuels, 1000 barrels daily; and avgas 4750 barrels daily. Socony-Vacuum Oil Company, East Chicago, Ind., $4,210,000, 100 percent increase catalytic cracking capacity.

Standard Oil Company (Ohio), Lima, $312,000, avgas. Standard (Ohio), Toledo, $1,240,000, 45 percent, and $2,910,000, 90 percent aviation alkylates. Standard Oil Company of California, Richmond, $1,187,000, benzene facilities. Sunray Oil Corporation, Scurry County, Texas, $7,654,460, 55 percent, gasoline project.

Taylor Refining Company, Corpus Christi, $1,952,000, 90 percent and $2,173,000, 65 percent, and $530,000, 40 percent, benzene and toluene facilities.

Warren Petroleum Corporation, Crossville, Ill., $40,350, 90 percent, for isopentane facilities. Warren Petroleum, Monument, N. Mex., $66,945, 100 percent, avgas.

Salt Lake City Refinery Scheduled for Expansion

Utah Oil Refining Company has announced a $1 million expansion at its Salt Lake City refinery. Six new gasoline and crude oil storage tanks with a capacity of 384,000 barrels will be installed northwest of the refinery. A 6-inch and 8-inch pipe line will be installed at a cost of $120,000 to connect the tanks to the refinery. Chicago Bridge and Iron Company will install the tanks.

Also scheduled is the conversion of an existing tank into a refrigerated container for storage of light distillates, the movement of a stabilizer tower, and erection of a $185,000 steam boiler and a $65,000 expansion of the water treating facilities at the refinery proper. Sterns-Roger Manufacturing Company has been awarded the contract to build the boiler and water treatment facilities.

Kellogg to Erect Deep Rock Lube Plant at Cushing

Deep Rock Oil Corporation has awarded a contract to The M. W. Kellogg Company for construction of a new lubricating oil plant to be built at Cushing, Okla. Other major construction which was only recently completed at the 18,000-barrel daily refinery, included a crude still, fluid catalytic cracking unit, research and business buildings.

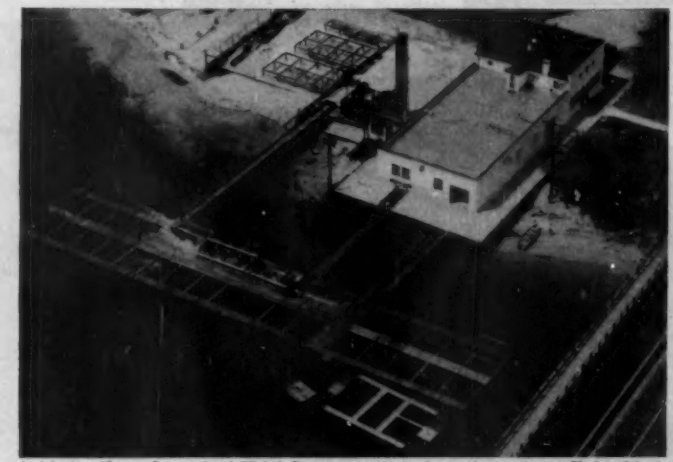
In addition to this latest project Deep Rock had earlier announced plans for the construction of a new blending and packaging plant for motor oils by the Chemical Plants Division of Blaw-Knox Construction Company.

The new lubricating unit will utilize propane deasphalting and the phenol solvent refining processes to produce

BRIDGEPORT BRASS COMPANY
CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

"Bridgeport" MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Aerial view of new International Nickel Co. sea water corrosion testing station at Harbor Island, Wrightsville, North Carolina.

Kure Beach Tests Help Lengthen Condenser Tube Life

Sea water corrosion testing of copper-base alloys continues to be an important phase of Bridgeport's Research Program. This work was originally started at the International Nickel Company's sea water corrosion test station at Kure Beach, North Carolina. It is now being carried on at Harbor Island, Wrightsville, North Carolina. During the past 8 years Bridgeport has tested thousands of metal samples.

Many test conditions closely approximate the "in-use" environments of condenser tubing installed in surface condensers operating with circulating sea water. Test samples are suspended in clean sea water flowing at a velocity of approximately two to three feet per second with a water temperature ranging from 35° to 85° F.

Test Procedure

Representative control samples were physically and chemically tested. Before assembly in special test racks, each sample was carefully annealed, cleaned, weighed and measured. The test racks were then submerged approximately 15 inches below the surface of the water.

At regular intervals (approximately 6 months) the test racks are removed for visual inspection and several are taken to the laboratory where they are dismantled for cleaning, weighing, inspecting, testing, and calculation of the rates of corrosion.

Results Found Helpful

Much valuable information was gained which has proved helpful in selecting copper-base alloys for sea water applications. We have been able to study impingement corrosion and the effects of alloy changes on pitting associated with impingement corrosion, and general surface pitting. We have also observed the extent and depth of corrosion based upon weight loss and loss in tensile strength, and the effect of metal hardness or temper on corrosion rate.

Since the results of the tests revealed those alloys with the greatest resistance to biofouling and corrosion in sea water, we have been able to improve them by modifying the amount of various alloying materials.

Improving Resistance To Impingement Corrosion

For example, one of the first things noted in connection with the test specimens was that the appearance of the leading edges varied considerably from one alloy to another. It was found that some of the specimens lost their sharp edges (see Fig. 1) and took on a rounded appearance. Those alloys which were most worn on the leading edge also had bright, clean leading edges without any visible corrosion film in this area. This led to a very marked decrease in the width of the specimens, and since the trailing edge of these specimens suffered very little change, the depth of corrosion on the leading edge could be measured directly with a micrometer.

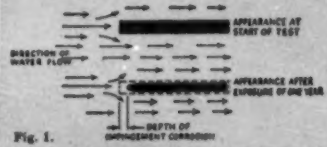

APPEARANCE AT START OF TEST
DIRECTION OF WATER FLOW
APPEARANCE AFTER EXPOSURE OF ONE YEAR
DEPTH OF IMPINGEMENT CORROSION

Fig. 1. Diagram showing the change in appearance of the leading edge of specimens due to impinging stream of sea water.

The final width of the specimen subtracted from the original width was called the depth of impingement corrosion. These measurements revealed that the following alloy changes led to marked increases in resistance to impingement corrosion:

(1) the combined addition of 5% aluminum and 0.25% arsenic to copper;

(2) the combined addition of 5% tin and 0.1% phosphorus to copper;

(3) the addition of approximately 0.5% iron to 70-30 cupro nickel;

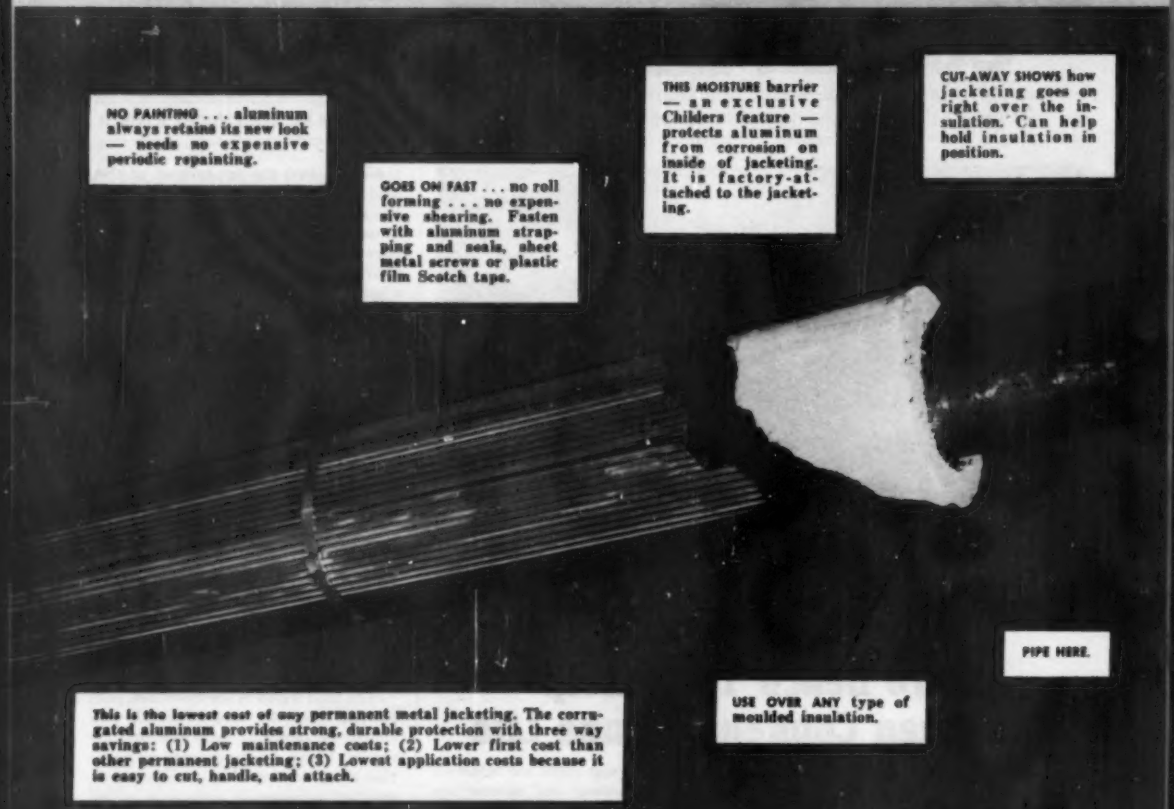
(4) the addition of 2% aluminum and 0.02% arsenic to 75-25 copper-zinc alloy.

The addition of arsenic or tin to Muntz Metal increased the rate of impingement corrosion. It is evident that, while uniform dezincification is in progress (as in the 60-40 brass, Muntz Metal), no impingement corrosion occurs. This indicates that the dezincification reaction overpowers the impingement corrosion reaction.

Additional information is constantly being gleaned from sea water tests. This is considered in conjunction with the results of other research carried on by the Bridgeport Laboratory to assist in getting longer service life from condenser and heat exchanger tubing.

(7583)

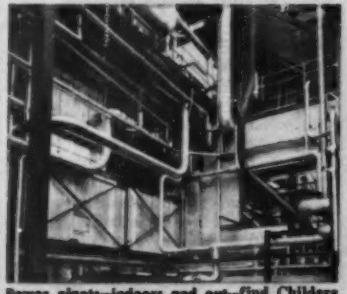
Save money—cut maintenance with


NO PAINTING . . . aluminum always retains its new look — needs no expensive periodic repainting.
GOES ON FAST . . . no roll forming . . . no expensive shearing. Fasten with aluminum strapping and seals, sheet metal screws or plastic film Scotch tape.
THIS MOISTURE barrier — an exclusive Childers feature — protects aluminum from corrosion on inside of jacketing. It is factory-attached to the jacketing.
CUT-AWAY SHOWS how jacketing goes on right over the insulation. Can help hold insulation in position.
PIPE HERE.
USE OVER ANY type of moulded insulation.

This is the lowest cost of any permanent metal jacketing. The corrugated aluminum provides strong, durable protection with three way savings: (1) Low maintenance costs; (2) Lower first cost than other permanent jacketing; (3) Lowest application costs because it is easy to cut, handle, and attach.

Childers Jacketing already in use in 567 of America's leading processing plants.

Oil refineries and gasoline plants had started to use sheet aluminum for protecting insulated lines even before Childers Jacketing was developed. They were tired of costly maintenance and repair with temporary materials. Now they are discovering that Childers Jacketing has even more advantages than expensive sheet aluminum—but costs less to buy and far less to apply.



Power plants—indoors and out—find Childers Jacketing their ideal material for protecting insulated lines as in this big Southern installation. Childers Jacketing is low in cost and easy to handle. More than that, it is a permanent-type weather protection that needs no painting. Its gleaming aluminum surface makes for "good housekeeping" in any utility or industrial power station.

Chemical and food plants such as this plant of the Minute Maid Corp. at Leesburg, Florida, like the low cost, low maintenance, and neat appearance of Childers jacketing. Indoors in food plants aluminum maintains that spotless look and can easily be washed. Outdoors in the tough corrosive atmosphere of most chemical plants the 3S alloy used for Childers Jacketing gives maximum life.

Childers Jacketing for insulated lines

Easy to apply—Childers Jacketing cuts man-hours

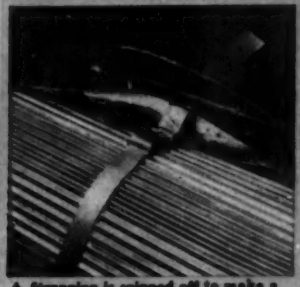
1. This is how easy it is to cut and handle Childers Jacketing right on the job. The four-foot-wide roll can be run out and cut to lengths by one man using a dull knife and a straight-edge. This cuts preparatory labor.

2. Best method of attaching jacketing is with aluminum strapping and seals. Here a seal is placed on end of strap, preparatory to putting it around the jacketing. This can all be done easily by hand; no tool or machine needed.

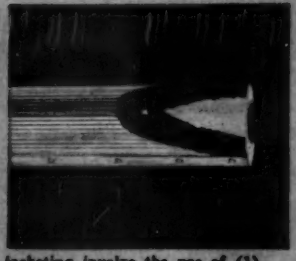
3. A two-man crew can apply the jacketing fastest. No special shop work or roll forming is necessary. Only tools are a pair of pliers and a wedge or screw driver as shown here. Note how easily the jacketing forms around the pipe.

4. Aluminum strapping can be pulled plenty tight enough with just pliers like this. No special strapping tool needed. Wooden wedge is useful substitute for screw driver. Strapping is next pulled down between lugs.

5. Lugs are bent over easily, but hold strapping securely and permanently in position. If line is moved, lugs can be bent up to release strapping. Seals, strapping, and jacketing itself can be re-used in this case.



6. Strapping is snipped off to make a neat job, and the workman is ready to go on to the next strapping point. Minimum number of straps hold flexible Childers Jacketing firmly and snugly in place.



Two alternate methods of attaching the jacketing involve the use of (1) Minnesota Mining's No. 471 Plastic Film Scotch Tape; or (2) aluminum sheet metal screws. All methods are satisfactory; but aluminum strapping and seal method is probably best all-around.

Under CMP regulations, Childers is a Class B product, the use of which is not restricted.

There are Childers Engineering representatives in every principal city. They are anxious to help you with your jacketing problem. Write for name of engineering representative nearest you. Address Childers Manufacturing Co., Dept. PR-7, 625 Yale St., Houston 7, Texas.

CHILDERS
ALUMINUM WEATHER-PROOF
Jacketing

high quality lubricating oils. Engineering is already begun on the project which will have a processing capacity of 930 barrels daily, and the completion date is projected for December, 1952.

Imperial's Expansion Plan Extended to Ioco Refinery

Imperial Oil Company has extended its expansion program to include the refinery at Ioco on Burrard Inlet in British Columbia, and will also announce construction at the Regina refinery as plans progress. Ioco's share in the $24 million program will include a new catalytic cracking plant.

Already underway are projects at Sarnia, Ontario, and at Edmonton, Alberta. The $14.6 million Sarnia project includes an atmospheric and vacuum distillation unit, a fluid catalytic cracking unit and a light-ends recovery plant which are being built by Canadian Kellogg Company. The $5.5 million Edmonton program is highlighted by a 20,000-barrel-per-day catalytic cracking unit which was engineered by Standard Oil Development Company, and being erected by Foster Wheeler.

Sunray Restores Alkylation Production at Duncan Plant

Rehabilitation work on the dormat alkylation plant located at Sunray Oil Corporation's Duncan, Okla., refinery is underway and will give the plant a production of about 2000 pounds of alkylate per day when the unit is completed in August, 1952. The rehabilitation work is estimated at $1.7 million.

Scheduled new construction at the refinery includes increased capacity of the catalytic cracking unit for greater production of propylene tetramer. Refinery Engineering Company of Tulsa will handle this assignment and will remodel the catalytic blower to supply a larger quantity of air for regeneration of the cracking catalyst.

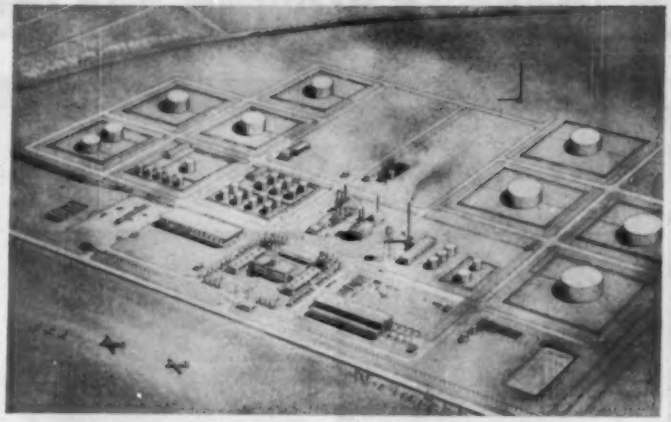
Leghorn Capacity Increased To 30,000 Barrels Crude

Latest information from Italy reports that work at the Stanic Industria Petrolifera Company of Rome, covering installation of a two-stage pipestill, phenol extraction, propane dewaxing, clay contacting and lube acid treating plants at its Leghorn refinery, as well as rehabilitating the crystalline wax facilities, is progressing on schedule.

When the project is completed the refinery will have a crude run capacity of 30,000 barrels a day; 1166 barrels daily of finished lubricating wax; and 240 barrels daily of finished crystalline wax. The total refinery capacity is reported at 15,500 barrels per day.

New Carbon Black Plant Scheduled for Sarnia Site

Cabot Carbon of Canada, Ltd., has engaged Stone & Webster of Canada to build a 20 million pound oil furnace carbon black plant at Sarnia. It is hoped that the Canadian government will permit priorities so that the plant may be in operation early in 1952.



ENGINEERING AND DESIGN work are underway on this refinery being built for Kefinaria de Petroleos de Manguinhos S. A. by The M. W. Kellogg Company on the outskirts of Rio de Janeiro, Brazil. A 10,000-barrel-a-day plant, it will consist of a single-unit thermal-cracking refinery combining topping, vis-breaking, gas-oil cracking, naphtha reforming and gas recovery operations, and is scheduled for completion the second half of 1953.

Minnesota Plant Adds Catalytic Cracking Unit

Procon, Inc., has been engaged to handle the building of new catalytic cracking and gas recovery units for Northwestern Refining Company of St. Paul Park, Minnesota. The new units, for which ground was broken late last month, are part of an extensive improvement and expansion program to increase the crude processing capacity from 8000 to 30,000 barrels daily.

Application has been made for certification by the Defense Production Administration of a new 30,000-barrel-a-day skimming unit to augment present facilities and those now under construction.

Contracts Awarded for Illinois Petro-Chem Plant

Ground has been broken at Tuscola, Ill., where National Petro-Chemicals Corporation is building a $32 million plant. The feed capacity of the unit will be 5000 million cubic feet of wet gas daily when the plant is in operation late next year. Contracts have been awarded as follows: Vulcan Copper Company, Cincinnati, for the ethyl alcohol unit; J. F. Pritchard, main absorption plant and utilities; Lummus, ethylene unit; Foster Wheeler Corporation, ethyl Chloride unit.

B-A Announces Arrangements For Ontario Grease Plant

British American Oil Company has announced plans to build a $1.5 million grease plant at its Clarkson, Ont., refinery. Scheduled for completion by late 1952 the plant is expected to reduce imports of U. S. grease. Plant capacity is designed at 15 million pounds of grease annually.

Canadian Chemicals Need To Be Met by New Plant

The new chemical plant which Canadian Chemicals Company, Ltd., an affiliate of Celanese Corporation of America, has announced it will build in Edmonton, Alberta, will produce methanol and propylene glycol among other chemicals not now produced in Canada. The chemicals will be manufactured in sufficient quantity to meet the major portion of Canadian demand according to Harold Blancke, president of both companies. A few products will be available for export as well. Sales offices for the new company are being established in Montreal.

Hudson Begins Construction Of Pegasus Field Gas Plant

An initial capacity of 30,000 million cubic feet per day of casinghead gas is planned for the new gasoline plant that Magnolia Petroleum Company will erect to serve the Pegasus field in Midland and Upton counties, Texas. Over 100,000 gallons daily of natural gasoline, butane and propane will be manufactured when the plant is in operation. Hudson Engineering Corporation of Houston will begin construction of the absorption type plant this month.

Three Year Expansion Plan Is Underway at Wood River

Expansion and modernization on a three-year scale has begun at Shell Oil Company's Wood River, Ill., plant. The $42.5 million program will add 50,000 barrels daily to the plant capacity, and will replace obsolete equipment. Amortization granted was 75 percent on refining equipment, 100 percent on alkylation equipment.

Sinclair Awards Badger Sulfur Extraction Contract

Contract has been awarded the Badger Process Division of Stone & Webster Engineering Corporation to erect a 10,000-barrel-a-day sulfur dioxide solvent extraction plant for Sinclair Refining Company at its Wood River, Ill., plant.

Further construction items on page 182.

HUDSON SOLO-AIRE EXCHANGERS

Pictured above is an installation of HUDSON SOLO-AIRE JACKET WATER COOLERS providing cool water to the power cylinders, compressor cylinders, and lubricating oil coolers of ten 800 horsepower gas engine driven compressors. The coolers, operating with inlet air temperatures ranging seasonally from below zero to 105°F, deliver cool jacket water at a *uniform, controlled* temperature the year around.

For this installation the great expense of obtaining and treating raw water determined the selection of HUDSON SOLO-AIRE units—rather than HUDSON water cooling tower with HUDSON water-cooled units. The use of air-cooled units in this compressor station precluded the loss through evaporation of about 90 gallons per minute of raw water.

HUDSON SOLO-AIRE units are in use in a great variety of process cooling and condensing services in chemical plants, refineries, and gas processing plants.

OTHER HUDSON "TP" COOLING EQUIPMENT

Bulletins on HUDSON TOP PERFORMANCE COOLING EQUIPMENT mailed upon request

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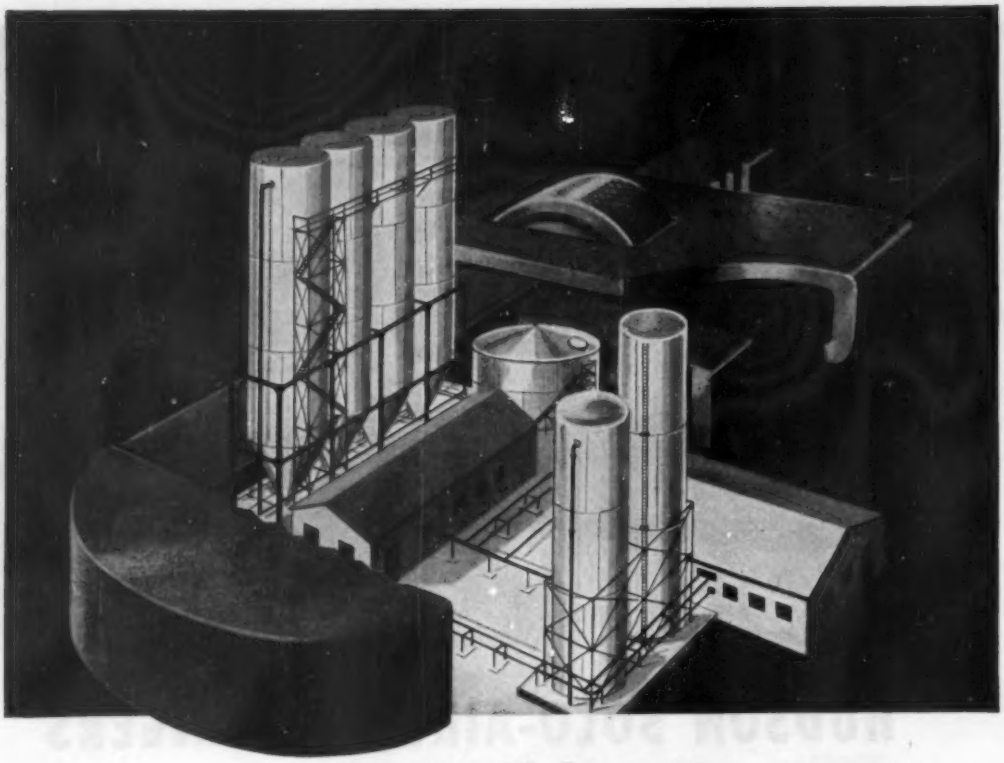

How to Tighten Up a Process When the Profits Work Loose

Can your operation bring more income? Probably. Most can. Here's how a refiner handling sour crudes went about it. He wanted economical flashing of a lube cut at 750°F to a furfural refining stock.

He got it with a stainless-clad steel flash tower built for semi-automatic operation. The design economically assures resistance to thermal shock, protects against elevated temperature corrosion and provides necessary strength and rigidity.

This refiner got continual throughputs of 20,000 barrels a day with long on-stream service. Other design bonuses were low maintenance, long life, reduced manpower needs.

Peak equipment values like this are the result of cooperative development between the engineering staffs of progressive Equipment Builders, process engineers and material suppliers. In developing such equipment, these experienced builders regularly turn to Lukens for its knowledge of materials, as well as its wide range of specialty steel plate, heads and steel plate shapes providing essential design freedom, strength and rigidity.

Get this attention for your operation. For names of Equipment Builders who can help you, write us today, explaining your need. Manager Marketing Service, 404 Lukens Building, Coatesville, Pennsylvania

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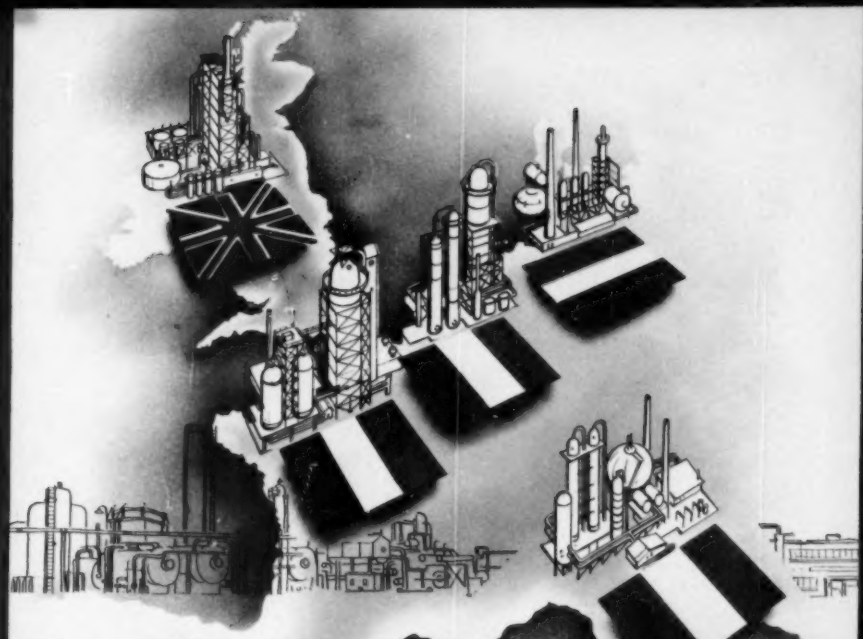


From Kerosine to Petro-Chemicals ...on the European Continent!

Kellogg engineers have been working with international refiners since the days when kerosine accounted for a third of the liquid product sales . . . and pot stills were standard equipment. Subsequently, much of Europe's thermal cracking and other refining facilities were supplied by Kellogg.

Through the years, Kellogg has built complete refineries and refining units for the Continental affiliates of such international companies as Esso, Shell and Anglo-Iranian, as well as for the major national refiners of Belgium, France and Italy.

Currently, several major Kellogg-designed plants are under construction . . . at Antwerp, Belgium; at Dunkirk and Gonfreville, France; at Ferrara, Italy. These projects encompass one complete refinery and many individual process units. Refining processes being utilized include atmospheric distillation, visbreaking, thermal cracking and reforming, propane deasphalting, Furfural treating, and Fluid catalytic cracking for the British Isles. Allied, though not an actual refining project, is Italy's first plant to produce olefins and their petro-chemical derivatives. This latter is Europe's second such plant, the first one having been designed by Kellogg for Imperial Chemical Industries in England.

THE M. W. KELLOGG COMPANY

A SUBSIDIARY OF PULLMAN INCORPORATED

for fifty years an integral part of processing history

NEW YORK JERSEY CITY LOS ANGELES TULSA HOUSTON TORONTO LONDON PARIS

Portrait at

This year is Kellogg's fiftieth of service to industry. At this time naturally, as a group of men—known collectively to the modern business world as The M. W. Kellogg Company—we can think back nostalgically. We can remember the chimney stacks

"In the Final Analysis..."

In previous issues of this magazine, "camera portraits" of M. W. Kellogg today have highlighted major aspects of Kellogg's operations, from basic research through the many steps to job-site construction.

This month, the camera takes a parting look at the construction lot and then focusses, through other company activities, on the over-all picture of Kellogg's service to industry.

1. *KELLOGG'S CONSTRUCTION FORCE* is permanently staffed, right down to key craft foremen. This proves particularly advantageous in the specialized installation of high-pressure, high-temperature utility power piping. Accurate pre- and post-heat as well as welding procedures must be followed to insure perfect fabrication of the alloys now being used for this type of service.

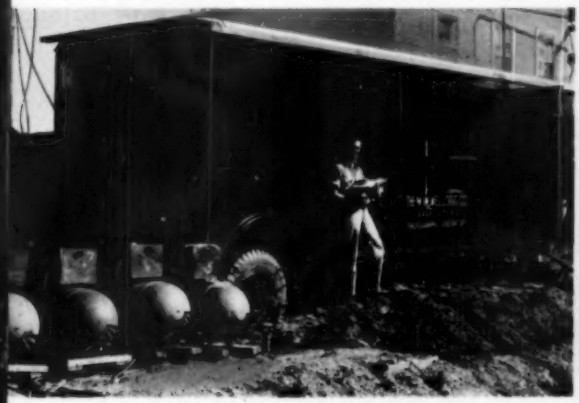
4. THE "PAY-OFF" in Kellogg's business is revealed by two ostensibly unrelated activities—accounting and initial operation of equipment or plants. Both contribute to the final evaluation of a job: *How well did it work out cost-wise? How well does it perform the job for which it was designed?* From this office Accounting Control is exercised over all Kellogg projects. Spotlighting true costs of even minor activities, this department illuminates the path to lower costs and keeps field supervisors continually cost conscious.

5. *"OPERATING INSTRUCTIONS"* are delivered to customers with completed Kellogg process units. The *practical* operating men who "build" these books start on the task with the inception of each project in the Design Engineering Department. In this way, they make certain that all features required by the customer for efficient operation are incorporated in the final design.

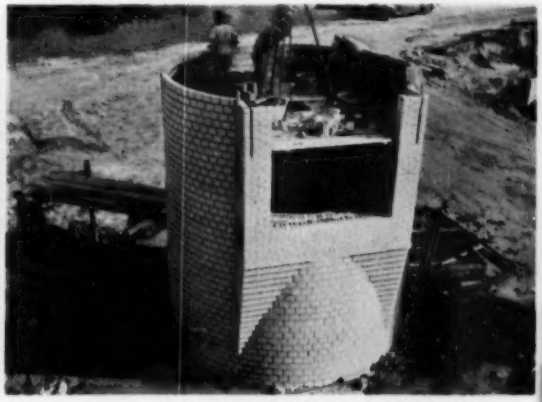
Fifty... nil

M KELLOGG W
1901-1951
50th Anniversary

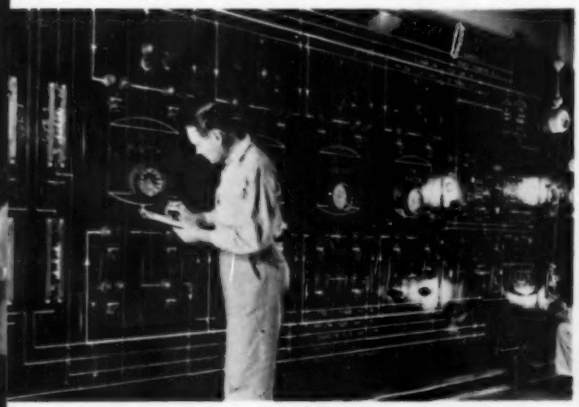
we built in 1901 . . . the first crude vessels for oil refiners in the 'teens . . . our first combination unit . . . the forty-odd Fluid cat crackers built in these years. But, after all, The M. W. Kellogg Company is only a factor as it is able to serve industry <u>today</u>. For that reason, we are presenting this series of monthly camera studies which document our belief that a truly integrated organization can better serve industry to achieve greater earning power. This is <u>No.11</u> in the series.



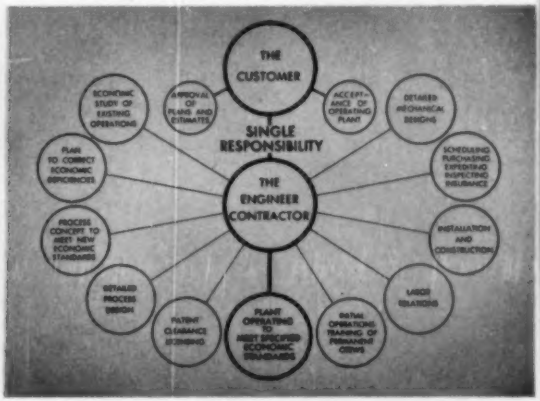
2. ***BOTH THE GAMMA AND X-RAY*** testing equipment, usually associated only with the highest quality shop fabrication, are taken *out into the field* by Kellogg. Originally, much of the equipment was not only specially designed, but in some cases built by Kellogg people. Pictured is one of the company's complete test laboratories-on-wheels.



3. ***COMPLEMENTING THE CONSTRUCTION DEPARTMENT*** is a division that concentrates on the erection, maintenance and repair of radial brick, common brick and concrete industrial chimneys. This activity has been a Kellogg specialty for nearly fifty years, and a complete staff of chimney engineers provides both new chimney design and an inspection service.



6. ***SUBSEQUENTLY, THESE MEN*** go into the field and personally check to see that each part of a new unit is completely operable in accord with design specifications. Then, they stand by in an advisory capacity to the customer's regular operating crews throughout the period of initial operation.

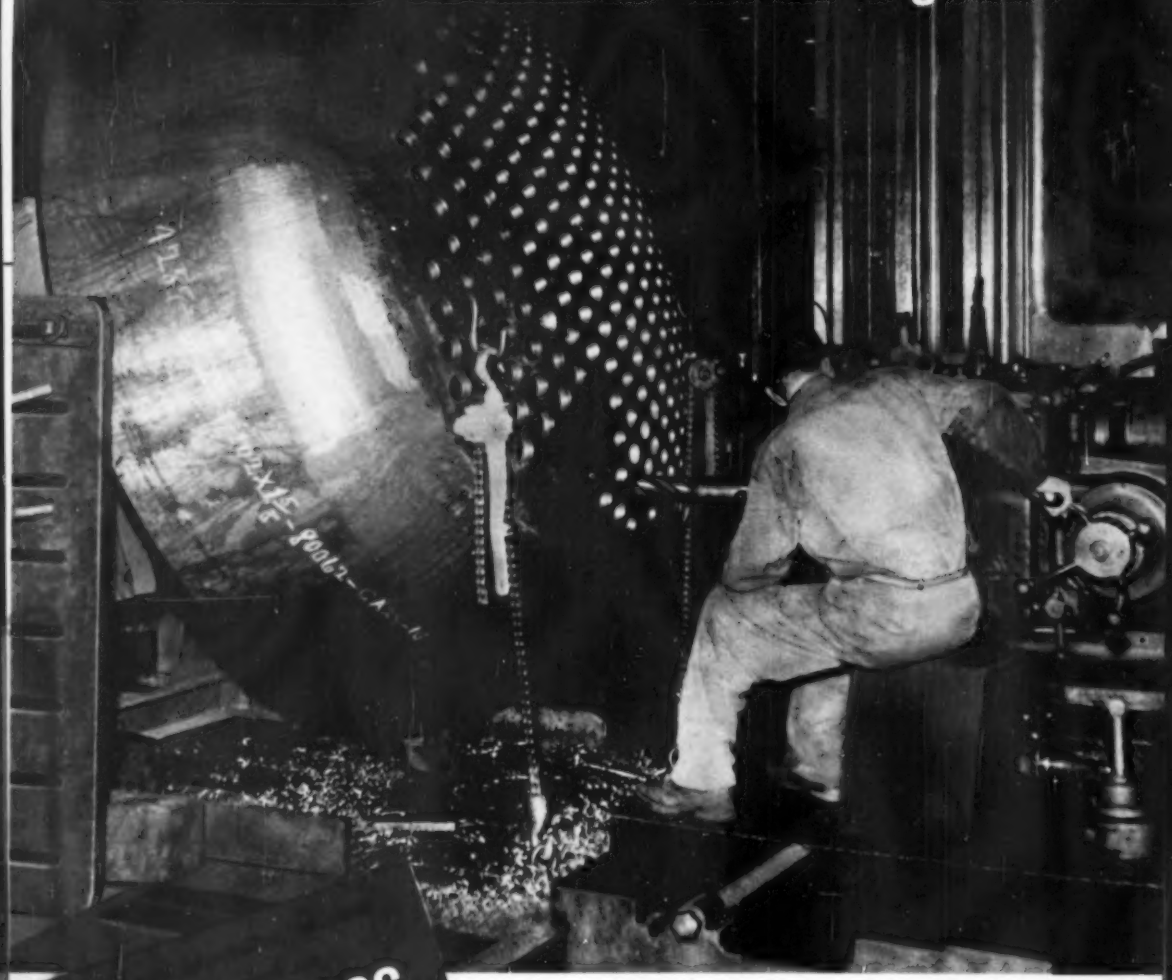

THE CUSTOMER
SINGLE RESPONSIBILITY
THE ENGINEER CONTRACTOR
ECONOMIC STUDY OF EXISTING OPERATIONS
APPROVAL OF PLANS AND ESTIMATES
ACCEPTANCE OF OPERATING PLANT
DETAILED MECHANICAL DESIGNS
PLANS TO CORRECT ECONOMIC DEFICIENCIES
SCHEDULING PURCHASING EXPEDITING INSPECTING INSURANCE
PROCESS CONCEPT TO MEET NEW ECONOMIC STANDARDS
INSTALLATION AND CONSTRUCTION
DETAILED PROCESS DESIGN
LABOR RELATIONS
PATENT CLEARANCE SECURING
PLANT OPERATING TO MEET SPECIFIED ECONOMIC STANDARDS
INITIAL OPERATING TRAINING OF PERMANENT CREWS

7. ***THUS IS KELLOGG COMPLETELY INTEGRATED*** to serve its customers from initial plan to operating unit . . . integrated to provide every factor, that can contribute *Greater Earning Power* and *Greater Value* to every customer's project.

P. S.

. . . this is the final camera study in the series presented during Kellogg's Fiftieth Anniversary year!

A thousand holes... to muffle a giant!



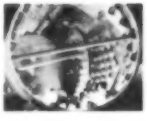
M. W. KELLOGG

Part of a huge muffler for a giant catalytic cracker, this perforated, dished, stack baffle is symbolic of Kellogg's especial forte in the field of heavy metal fabricating. It's a first of its kind . . . it requires unusual fabricating techniques . . . it's built to close tolerances!

Continuing Study of behavior of metals under stress at high temperatures has produced valuable design data.

Shop Layout Craftsmen are fully experienced in vessel fabrication from nozzle positioning to "knockdown" fabrication for field assembly.

Extensive Facilities from forming of plate to final machining of precision surfaces permit complete fabrication under the same roof.



Special Welding Techniques and stress relieving methods assure equipment performance even under severest operating conditions.

Rigid Quality Control, devised by specialists, including chemical and micro analyses as well as mechanical and non-destructive testing.

NEWS FOR OPERATORS IN WESTERN CANADA!

The Canadian Kellogg Company Ltd. has established complete shop facilities for the fabrication of all types of piping at **EDMONTON**, Alberta. Inquire directly or through any Kellogg or Canadian Kellogg office.

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The M. W. Kellogg Company *(A Subsidiary of Pullman Incorporated)* New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris

PETROLEUM
REFINER
DECEMBER, 1951

Fundamentals of FLUID HYDROFORMING

E. V. MURPHREE

Standard Oil Development Company, New York

THE petroleum refiner is primarily interested in filling the needs of the motor car owner as the largest single customer for petroleum products. The most important quality aspect of gasoline for this customer is antiknock performance because it is recognized so easily. Over the past twenty-five years the gasoline antiknock requirements have been increasing because of continually higher compression ratios in automobile engines to improve both car performance and fuel economy. The compression ratio of the average new car in the U. S. A. is 7:1 with a Research octane number requirement of about 89. The compression ratio of many cars may be increased to about 12:1, necessitating high octane number gasoline. Since the production of high octane number gasoline by normal refinery techniques is expensive, there is a large incentive for development of a new, low cost octane improvement process.

Octane Number Deficiency of Virgin Naphthas

Motor gasoline is a blend of many refinery streams, of which the cracked and virgin naphthas are the largest portions. The cracked gasolines are usually derived from catalytic cracking of gas oils to high octane number products. The virgin naphtha is the low octane number fraction of the crude oil which may be blended into gasoline without processing. The general effect of the virgin naphtha fraction on the gasoline pool may be appreciated by considering a fairly typical case, as, for example, a 50:50 mixture of East and West Texas crudes, from which the maximum yields of kerosine and middle distillates are removed by distillation, the heavy gas oil is catalytically cracked, the pitch is visbroken, and the available C_3 and C_4 olefins are polymerized. With no processing of the virgin naphtha, the gasoline pool has the quality shown in Table A.

It is apparent that if high octane levels are to be reached in the over-all gasoline pool, it is necessary to process the virgin component to high octanes

TABLE A

Gasoline Component	Volume Percent of Gasoline Pool	Research Octane No.	
		Clear	+ 2 cc. TEL/Gal.
Cracked + Polymer	44.4	94.6	98.6
Virgin	55.6	58.9	70.8
Total	100.0	80.6*	88.0*

* Predicted octane number of blend.

FLUID HYDROFORMING, one of the latest catalytic reforming processes, provides an economical means for reforming low-octane naphthas and straight-run gasolines into high quality components more suitable to meet the new demands for high-octane gasolines.

At the present time three fluid hydroformers are being constructed: One for Pan-Am Southern Corporation at the Destrahan, La., refinery, a second for Cities Service Refining Corporation at Lake Charles, and a third for Cities Service Oil Company at East Chicago, Ind. It is expected that the Lake Charles fluid hydroformer will handle up to 30,000 BPD of naphtha.

This paper, originally presented before the Third World Petroleum Congress, The Hague, May 28-June 6, 1951, presents the basic fundamentals of fluid hydroforming, its cost, and its application. On page 30 is a companion article, by H. G. McGrath, which gives the most recent results obtained in the operation of a fluid hydroforming pilot unit.

with good yields since it represents such a large portion of the total.

The chemistry of petroleum hydrocarbons offers a limited number of methods of improving the octane number of a virgin naphtha. Virgin naphthas are composed largely of paraffins, cyclohexanes, cyclopentanes, and aromatics with smaller proportions of other components such as sulfur compounds. Consequently, improved octane numbers may be obtained by:

a) Molecular weight reduction or cracking.

b) Olefin formation.

c) Isomerization to increase the branchiness of the molecule.

d) Cyclization and aromatization of paraffins.

e) Dehydrogenation of cyclohexanes to aromatics.

f) Isomerization and dehydrogenation of cyclopentanes to aromatics.

In addition to these reactions, the elimination of sulfur is also very desirable since it results in increased susceptibility of the gasoline to octane number increase by addition of lead tetraethyl. All of these reactions, with the exception of molecular weight reduction, are capable of giving high-octane products with good yields if processes of high selectivity can be developed.

At the present time most refiners are employing thermal reforming for octane number improvement of heavy virgin naphthas. Since the octane number of the C_6 — 200° F. fraction of virgin naphthas is in the order of 65-70 and the 200°-400° F. fraction in the range of 30-50, most octane number processes have concentrated on the heavier naphtha fraction which is subject to greatest octane number improvement. The thermal process is principally concerned with the cracking reaction to produce olefinic compounds of lower molecular weight. However, above Research octane number levels of about 90 clear (95 + 2 cc TEL), very high yield losses to light hydrocarbons are experienced for incremental octane number improvements. The large production of C_3 and C_4 olefins at high severities makes it necessary to complement the process with catalytic polymerization in order to improve yields and reduce the vapor pressure of gasoline.

Fundamentals of Hydroforming Process

An available method of octane improvement is hydroforming, which is essentially a catalytic dehydrogenation process, and, to a lesser extent,

paraffin isomerization, both of which reactions give very desirable yield-octane relationships. In addition, the process removes sulfur compounds and yields a stable gasoline. In existing hydroformer units a supported molybdena catalyst is employed in adiabatic fixed bed reactors at temperatures in the range of 900° to 1000° F. Pressures are normally in the range of 200-300 psig and hydrogen-rich gas, produced in the operation, is recycled at the rate of 3-4 mols per mol of feed in order to suppress carbon formation. This process, as installed in the early 1940's and with the catalyst available at that time, gave a 2-5 percent advantage in yield over thermal reforming plus olefin polymerization on a 10-pound RVP base at 90 Research octane number.

In recent years, intensive studies of the technology of the hydroforming process have led to a better appreciation of the factors which affect its yield-octane relationship. Much of the progress involves an understanding of the part which purely thermal reactions play in degrading the yield-octane relationship even when the extent of thermal conversion appears very small in comparison with the over-all reaction. Since the dehydrogenation in hydroforming is a highly endothermic reaction, in adiabatic large-scale reactors temperature drops of as high as 250° F. are experienced from the inlet to the outlet of the reactor. Thus, feed temperatures higher than the average reactor temperatures are required to offset the large negative heat of reaction in the process and an appreciable amount of thermal cracking of the feed is experienced.

The effect of thermal cracking of the virgin naphtha on the yield-octane relationship in subsequent hydroforming was extensively studied. Samples of feed from commercial preheat furnaces showed little conversion of C_5 and lighter gases, but pilot plant studies showed that even this amount of precracking had a significant effect on the octane of the hydroformate produced for the same operating conditions or the same yield. Apparently, precracking is accompanied by changes in hydrocarbon types which adversely affect the hydroforming results, as illustrated in the following comparison for precracking with only 1.2 percent conversion to C_5 and lighter gases.

For this comparison isothermal hydroforming was employed to minimize the effects of variables other than precracking on the final results. Precracking was varied by controlling the temperature of the preheating coil, and the 1.2 percent C_5-production corresponds to about the minimum thermal conversion which can be expected in a commercial unit of early design. The data indicate that a 2.5 percent improvement in yield is available through the simple expedients of minimizing furnace and transfer line contact time and decreasing the void volume on top of the catalyst bed necessary to properly distribute the feed to the entire reactor cross section. More severe yield losses, as large as 8 to 9 volume percent, have been observed under conditions where high feed preheat and reactor temperatures have been used to compensate for losses in catalyst activity.

	Isothermal Hydroforming	
C_5 and Lighter from Precracking, percent	0	1.2
CFRR Octane (Clear) of Hydroformate	90	
Hydroformate Yield, Volume percent	90	87.5

The high temperatures in the first increment of a fixed catalyst bed would be expected also to cause yield losses because of thermal cracking. This point is almost impossible to prove by simple experiments since alteration of the degree of thermal cracking in the bed requires the change of many other variables. However, extensive correlations of data for many catalysts under varying conditions of feed rate, temperature, pressure, etc., have demonstrated such undesirable effects to exist. Consequently, it is important to use catalysts of high activity and good stability, such as highly active molybdena-alumina gel catalysts, in order that minimum reactor temperatures may be used.

In addition to making possible less thermal cracking both before and in the catalyst bed because of lower inlet temperatures, isothermal operations, as compared to adiabatic hydroforming, have been shown in laboratory experiments to have substantial advantages. This is illustrated in the following tabulation which shows isothermal versus adiabatic operation with minimum precracking in each case:

Reactor Type	Isothermal	Adiabatic
Precracking	Minimum	
CFRR Octane (Clear) of Hydroformate	90	
Hydroformate Yield, Volume percent C_5+	90.0	84.5

No clear explanation is available for the superior yield in the isothermal reactor data, but it is believed to lie in the more selective conversion of naphthenes to aromatics at the somewhat lower inlet temperatures.

To summarize, these studies have indicated the following principles give the optimum yield-octane relationship in hydroforming: 1) minimum contact time in furnace and void reactor volume decreases thermal precracking, 2) catalyst activity as high as possible minimizes the temperatures required in the reaction zone, 3) an isothermal reactor has yield advantages over adiabatic operations. A comparison of results from a laboratory fixed bed hydroformer utilizing these principles with those for operations paralleling the early unit designs follows.

CFRR Octane (Clear) of Hydroformate	85	95
Hydroformate Yield, Volume Percent C_5+:		
Original Hydroformer	83.0	71.4
Improved Hudroformer	88.1	80.0

Fluid Hydroformer Design

Knowledge of the operating principles enumerated in the previous section led to an extensive study of the use of the Fluid solids technique in hydroforming because it was a method of attaining the optimum conditions. The Fluid technique of achieving vapor phase catalytic reactions has been highly developed in the Fluid catalytic cracking process which has been used commercially for the last ten years.

The principal elements of a Fluid hydroforming unit are shown in Figure 1. The reactor is a tall, cylindrical vessel with adequate internal insulation. The regenerated catalyst and heated recycle gas are introduced below a perforated grid plate and the oil vapors are added just above. The hydroforming reactions are consummated as the vapors pass upwardly through the dense bed of turbulent hydroforming catalyst. The larger portion of the catalyst suspended in the vapors leaving the dense bed is separated by gravity in the dilute phase in the top of the vessel. Little or no thermal cracking takes place in the top of the reactor because of the aromatic nature of the reaction products. Additional catalyst is removed from the vapors in two cyclones in series. To complete the catalyst recovery, the vapors are scrubbed with a cooled liquid stream of recycle hydrocarbons, the catalyst being separated from it in a filter for return to the reactor. The vapors are cooled in a heat exchanger with feed or recycle gas, and the gases and liquids are then separated in a drum, from which a portion of the gas is recycled by means of a compressor through heat exchangers and a fired heater to the reactor.

The spent catalyst is removed from the reactor through a standpipe with a control valve at the bottom and is transported by regeneration air to the regenerator. The construction of this vessel is similar to the reactor but it is much smaller. It is less than 10 percent of the size of the regenerator for a catalytic cracking unit of the same feed capacity because of the lower car-

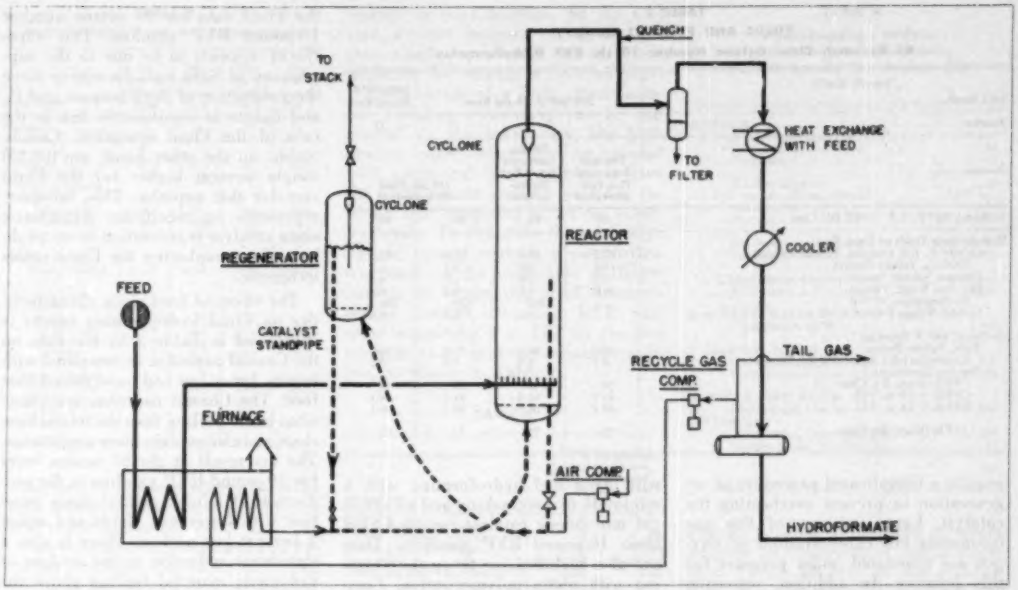

Figure 1. Fluid Hydroformer.

bon yield, the higher pressure, and faster burning rate of carbon on the hydroforming catalyst. The small amount of catalyst in the exit gases from the two cyclones in series in the top of the regenerator is less than that necessary to be added to the unit to maintain activity with the conventional molybdena-alumina catalyst. Complete catalyst recovery from the flue gases can readily be obtained if it should be desired to operate with more costly catalysts. Catalyst attrition is kept at a minimum by proper unit design. The hot regenerated catalyst is removed through a standpipe and returned to the reactor in suspension in the hot recycle gas.

The study of process fundamentals shows that a large yield advantage is realized for isothermal over adiabatic processing, and the inherent property of a Fluid bed to maintain isothermal conditions in a reactor is one of the salient features of the Fluid technique. In the regenerator of a catalytic cracker, for instance, air is introduced at about 300° F. in the presence of carbonized catalyst. Since the oxygen in the air is almost completely consumed, its temperature would rise to over 2500° F. were it not for the rapid and uniform transfer of heat to the small catalyst particles which are heated from 925° to 1100° F. Careful measurements in a vessel 40 feet in diameter with a Fluid bed 20 feet in depth have not disclosed temperature variations of over 5°-10° F. throughout the catalyst bed. In addition to the gain for an isothermal reactor, there is also a substantial advantage for the Fluid technique in the regeneration step. Since the hydroforming catalyst is sensitive to high temperatures, exact temperature control in this exothermic reaction is important in maintaining catalyst activity.

The deleterious effects of thermal cracking of the naphtha are appreciably decreased by the almost instantaneous mixing of gases and catalyst in a Fluid reactor. The naphtha inlet temperature can be maintained at a low figure, say, 950° F., by introducing the required reaction heat both by recycle gas and regenerated catalyst at temperatures higher than the reactor temperature. The extensive thermal cracking in the empty space in the top of the downflow fixed bed reactors necessary to obtain feed distribution is practically eliminated in the upflow Fluid reactor where the turbulence of the bed gives the desirable mixing of feed and catalyst.

The continuous flow of catalyst and vapors is the second major advantage of the Fluid technique. In contrast to the cyclic operations of the fixed bed, there is a continuous flow of feed naphtha through the reactor, air through the regenerator, and catalyst between the regenerator and the reactor. The number of vessels required is reduced and valving and piping are greatly simplified over the fixed bed design. Instead of the vessels being built for the dual service of reaction and regeneration with the necessary valves and piping, each vessel can be built for its own specific purpose.

Continuous catalyst flow in a Fluid unit is important from the point of view of catalyst utilization and activity since catalyst can be added or removed as desired. If changes in feed stock or quality requirements occur, the severity can be altered by varying the space velocity in the reactor by raising or lowering the catalyst level. The optimum temperature can be maintained thus, rather than using the expedient of higher or lower temperatures to alter the severity of processing with a fixed amount of catalyst. Use of the operating temperature as a primary control is a debit to the fixed bed process both in added furnace cost and the octane loss due to thermal cracking in the furnaces at the higher temperatures. Since the Fluid system does not require a major turnaround for catalyst replacement, because catalyst can be added continuously, the activity level or the stability of the catalyst is considerably less important. Moreover, the control of severity by catalyst level in the reactor gives products of constant quality day by day rather than a degradation of product quality as the catalyst activity decreases during a run.

Regeneration is simplified to a marked degree in a continuous Fluid system since no temperature control is necessary other than a heat balance around the regeneration vessel. In fixed bed regeneration, high temperature zones caused by "flame fronts"

TABLE 1
YIELDS AND PRODUCT QUALITY
85 Research Clear Octane Number 10 Lb. RVP Hydroformates

Feed Stock	200/400° F. Mixed Base			200/330° F. Mixed Base
Number	I			II
Process	Thermal Reforming Plus Polymerization	200 psi. Improved Fixed Bed Hydroforming	200 psi. Fluid Hydroforming	
10-Pound/400° F. E.P. CFRR ON Clear	85	85	85	85
Hydroformate Yields on Fresh Feed:				
C_4/400° F. E.P. Gasoline, Volume Percent	83.1	89.5	90.0	91.8
Total C_4, Volume Percent	6.4	6.3	5.8	6.2
Polymer, Volume Percent	3.1	1.0	1.7	0.5
Dry Gas, Weight Percent	16.0	8.1	6.5	6.4
H_2 Production, SCF/B	....	580	450	640
Carbon, Weight Percent	....	0.4	1.4	0.5
10-Pound/400° F. Gasoline:				
Yield, Volume Percent	87.0	96.1	97.2	98.0
Extraneous n-C_4 Added, Volume Percent	3.9	6.6	7.2	6.2
Gasoline Inspections:				
CFRR Octane No. Clear	85	85	85	85
CFRR + 2.0 cc. TEL	91.9	94.4	94.4	94.4
CFRR + 3.0 cc. TEL	93.4	96.1	96.1	96.1
ASTM Octane No. Clear	72	77	77	78

require a complicated procedure of regeneration to prevent overheating the catalyst. Large volumes of flue gas containing low concentrations of oxygen are circulated under pressure for this purpose. In addition, provision must be made for purging after each phase of the cycle.

Fluid Hydroforming Data

The potential advantages of Fluid over fixed bed systems of hydroforming have been demonstrated and may be evaluated by comparative data. The tabulation in Table 1 compares Fluid results on a mixed base heavy naphtha with fixed bed hydroforming with a minimum of precracking and an active gel molybdena catalyst for 85 CFRR clear 10-pound RVP gasolines. Data are also included for thermal reforming with olefin polymerization. Comparative results for 95 CFRR clear gasolines are given in Table 2. Data for Fluid operations on different feed stocks are included to illustrate the trends with variations in feed properties. Detailed feed stock inspections are given in Table 3.

When comparing gasoline yields for the Fluid and fixed bed processes, there is a 5.5 volume percent advantage for the Fluid data for 95 octane number 10-pound RVP gasoline. This superiority appears to be due to the suppression of light ends formation since the production of both butanes and C_3 and lighter is significantly less in the case of the Fluid operation. Carbon yields, on the other hand, are 0.6-1.0 weight percent higher for the Fluid case for this naphtha. This, however, represents no significant drawback since catalyst regeneration is no problem when employing the Fluid solids technique.

The effect of feed stock characteristics on Fluid hydroforming results is illustrated in Table 2 by the data on the Coastal naphthas as compared with results for a low end point mixed base feed. The Coastal naphthas are somewhat lower boiling than the mixed base stock and also contain more naphthenes. The net result at the 95 octane level for 10-pound RVP gasoline is the production of 2.5-7.2 percent more gasoline with lower gas yields and about 1 percent less carbon. There is also a significant reduction in the amount of polymeric material boiling above the gasoline range. Undercutting the mixed base naphtha gives less high boiling polymer and less carbon.

The process advantages shown for Fluid over fixed bed must be attributed almost entirely to the attainment of a completely isothermal operation in the Fluid reactor as compared to the adiabatic operation in the best fixed bed case. In these pilot plant data minimum precracking was maintained by careful control of the naphtha preheater and, therefore, this variable was not a factor in the comparison.

In the above studies covering development of Fluid hydroforming, a molybdena-alumina gel catalyst was employed. Other catalysts are available which give superior yields to the molybdena-alumina catalyst. These catalysts should likewise show to advantage in the Fluid design and enhance the economic position of Fluid hydroforming in the present-day refinery picture.

TABLE 2
YIELDS AND PRODUCT QUALITY
95 Research Clear Octane Number 10 Lb. RVP Hydroformates

Feed Stock	200/400° F. Mixed Base		200/330° F. Mixed Base	200/330° F. Coastal No. 1	200/330° F. Coastal No. 2	
Number	I		II	III	IV	
Process	Thermal Reforming Plus Polymerization	200 psi. Improved Fixed Bed Hydroforming	200 psi. Fluid Hydroforming			
10-Pound/400° F. E.P. CFRR Octane No. Clear	95	95	95	95	95	95
Hydroformate Yields on Fresh Feed:						
C_4/400° F. E.P. Gasoline, Volume Percent	69.0	81.1	83.6	84.4	86.6	86.7
Total C_4, Volume Percent	8.7	9.2	8.4	9.2	6.6	9.3
Polymer, Volume Percent	5.9	1.6	2.4	0.7	0.4	1.0
Dry Gas, Weight Percent	26.5	15.0	10.3	11.7	9.2	8.7
H_2 Production, SCF/B	....	580	450	640	540	320
Carbon, Weight Percent	....	1.2	1.8	0.9	0.7	1.3
10-Pound RVP Gasoline:						
Yield, Volume Percent	69.0	79.0	84.5	83.8	91.7	88.0
Extraneous—n-C_4 Added, Volume Percent	0.0	....	0.9	....	5.1	1.3
Excess C_4 over 10-Lb. RVP, Volume Percent	0.0	2.1	....	0.6	....	....
Gasoline Inspections:						
CFRR Octane No. Clear	95	95	95	95	95	95
CFRR + 2.0 cc. TEL	98.6	100	100	100	100	100
CFRR + 3.0 cc. TEL	99.4	101	101	101	101	101
ASTM Octane No. Clear	79	82	83	84	84	84
RVP, psi.	10.0	10.0	10.0	10.0	10.0	10.0
Distillation (D Only):						
Percent Off at 158° F.	16.5	13.5	16.5	....	....	16.0
212° F.	28.0	25.5	30.0	25.5	27.0	30.0
257° F.	60.0	48.0	51.0	54.5	61.5	61.5
302° F.	78.5	79.0	81.0	83.0	90.0	91.5
356° F.	....	92.5	97.0	95.0	....	....
Loss, Volume Percent	2.0	2.0	2.0	2.0	2.0	2.0
Sulfur (Lamp), Weight Percent	....	<0.002	<0.002	....	....	....

Fluid Plant Investment

The investment savings in a Fluid hydroformer were established by comparing the cost of a Fluid design employing pressure of 200 psig and a temperature of 900° F., with that for a modern fixed bed unit. Although data are available for both processes only on a low octane number mixed base naphtha (No. I, Table 3) with a normal molybdena-alumina gel hydroforming catalyst, the improvements shown by the Fluid technique are thought to be representative of those which would be obtained for other

TABLE 3
Hydroforming Feed Stock Inspections

Feed Stock	200/ 400° F. Mixed Base	200/ 330° F. Mixed Base	200/ 330° F. Coastal No. 1	200/ 300° F. Coastal No. 2
Number	I	II	III	IV
Inspections				
Gravity, °API	53.3	55.0	53.7	55.5
Aniline Point °F	128	124	113	122
Naphtha Distillation, °F.				
5 percent at	248	237	235	235
50 percent at	282	262	255	252
90 percent at	346	305	295	281
Sulfur (Lamp), Weight Percent	0.113	0.066	0.040	0.046
Type Analysis, Volume Percent				
Olefins	0	0	0.3	0
Aromatics	8.2	8.5	13.6	10.3
Naphthenes	42.6	44.0	40.9	41.0
Paraffins	49.2	47.5	45.2	48.7
Octane Numbers				
ASTM—Clear	38	46.8	52.1	48.1
CFRR—Clear	43	48.8	55.8	52.5
CFRR + 2 cc. TEL	86	63.8	71.0	....

catalysts and naphthas when producing high octane number gasolines of low Reid vapor pressure.

The comparative investment and operating costs for the Fluid and fixed bed units for 95 clear octane number hydroformate are given as per Table B. The wide cut mixed base naphtha in the above comparison is a more refractory feed stock than the average refinery naphthas. Therefore, the investments are somewhat higher than normally required for this operation.

The foregoing estimates are based on March 1950 U.S.A. construction costs for a Gulf Coast refinery. The products from the units are stabilized and available for blending in finished gasoline with conventional refinery handling methods. The breakdown of the utility requirements for the Fluid unit is presented in Table 4.

The Fluid hydroformer has a substantially lower initial plant investment and lower daily operating costs. When combined with the yield savings, the Fluid process was estimated to produce gasoline of this high quality for about 40 cents per barrel less than the improved fixed bed process.

In situations where present gasoline quality tolerates a lower octane number hydroformate, two procedures are worthy of consideration. In the first case, a plant designed for the low octane number produced can be built, while in the second, a smaller plant for production of a high octane number blending component can be employed. In the latter case, the high quality hydroformate may be blended with additional feed naphtha to give the same octane number as from the larger unit operating at milder severity levels. To illustrate the advantage for the second method, a comparison was made for the production of 10,000 barrels per stream day of 95 Research octane number 10-pound RVP gasoline containing 2 cc TEL by the two methods from undercut refinery naphtha, as shown in Table C.

TABLE B
10,000-Barrel Per Stream Day Hydroforming Plants
Mixed Base Naphtha to 95 Clear Research Octane Number C.+ Product

	Fluid	Fixed Bed
Investments, Onsite	$4,350,000	$7,370,000
Utilities	190,000	390,000
Total	$4,540,000	$7,760,000
Initial Catalyst Cost	$ 285,000	$60,000
Yield, 10-Pound RVP, Volume Percent	84.5	79.0

TABLE C

PRODUCT	10,000 B/SD Leaded 95 Research Octane Number, 10-Pound RVP Gasoline (2 cc. TEL)	
C4+ Hydroformate, Research Octane Number, Unleaded	85	95
Unit Capacity, B/SD Feed	10,000	7,100
Investment	$2,500,000	$2,350,000
Investment Cost/Bbl. of Blend/SD	$250	$235

The lower investment and operating cost for the high octane number hydroformate operation indicates this to be the preferred method of producing the 95 leaded octane number (2 cc TEL) gasoline. In this study a more favorable feed stock was employed than in the previous tabulation. The above costs are for Gulf Coast, U.S.A., locations and 1950 construction cost level.

No economic study of hydroforming is complete without consideration of the cost of conventional thermal reforming as an alternate process. For the quality of gasoline in this study, catalytic polymerization equipment is required to recover the propylenes and butylenes as gasoline to give a satisfactory yield-octane number relationship. This involves gas recovery, and catalytic polymerization equipment in addition to the conventional thermal coil with rerun and stabilization towers. For production of the foregoing 10,000 barrels per stream day of 95 leaded Research octane number 10-pound RVP gasoline (2 cc TEL) this equipment costs about $4 million and about 12,000 barrels per stream day of feed naphtha are required as compared to 10,000 barrels per stream day for hydroforming with field butane available. The high investment and low yield of the thermal process make Fluid hydroforming an important factor in any future refinery operations.

Conclusions

Fluid hydroforming represents a distinct advance in the field of octane number improvement of virgin naphthas. Partly because of the elimination of precracking of the feed and partly because of the isothermal operation of the reactor, a superior yield-octane relationship over best fixed bed hydroforming is obtained. The inherent mechanical simplicity of continuous reaction and regeneration enables a substantial reduction in investment and operating costs. Since no functional process limitations such as maximum carbon or restrictive high temperatures in regeneration exist in the Fluid system, units can be designed for any octane number product or any type of feed. Moreover, the merits of improved catalysts can be exploited to maximum advantage in the Fluid process.

The yield and cost superiority of Fluid hydroforming over thermal reforming when using molybdena-alumina gel catalyst is of such magnitude that substitution of the process for existing reforming equipment is attractive. When considering increased refinery capacities, the investment cost of the new Fluid equipment and associated refinery facilities is considerably less for the same gasoline yield. With improved catalysts, the position of Fluid hydroforming is further enhanced.

The low costs and high yields engendered by the use of Fluid hydroforming thus make available higher octane number gasolines than considered economic in the past. As such, it offers an answer to the petroleum industry for high octane gasolines for the ever-increasing compression ratios of internal combustion engines.

TABLE 4
Hydroforming - Utilities and Chemical Requirements
10,000 Barrels Per Stream Day Fluid Plant

A. STEAM	
1. High Pressure Steam, Lbs./Hr.	(300 psi.)
Consumption	15,700
Production	14,000
Net Requirement	1,700
2. Low Pressure Steam, Lbs./Hr.	(125 psi.)
Consumption	15,000
Production	16,000
Net Production	1,000
Required for Start-up	9,000
3. Exhaust Steam, Lbs./Hr.	(20 psi.)
Production	14,500
B. COOLING WATER, 85° F.	
Consumption, GPM	5,700
C. ELECTRIC POWER	
Connected Load, KW	110
Normal Consumption, KW	95
D. BOILER FEED WATER	
Consumption, Lbs./Hr.	35,000
E. FUEL GAS	
Consumption, Onsite, MMBtu./Hr.	140
Utilities, Offsite, MMBtu./Hr.	10
	150

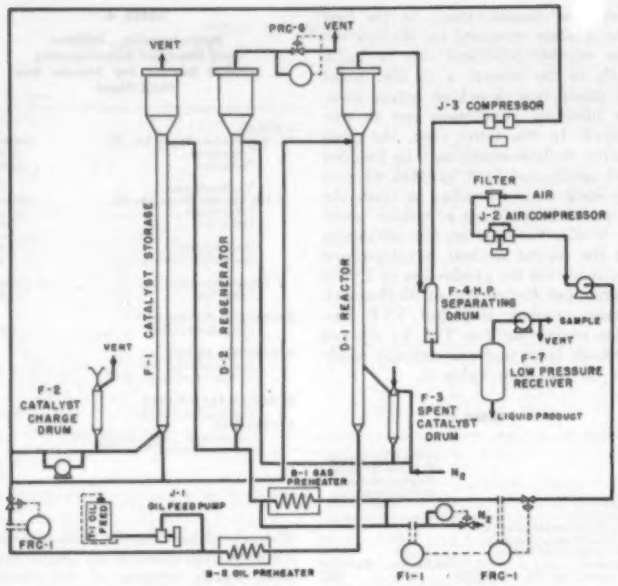

Figure 1. Flow Diagram of Fluid Hydroformer Pilot Plant.

The Application of FLUID HYDROFORMING

HENRY G. McGRATH

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AT THE PRESENT time three fluid hydroformers are being constructed: One for Pan-Am Southern Corporation at the Destrahan, La., refinery, a second for Cities Service Refining Corporation at Lake Charles, and a third for Cities Service Oil Company at East Chicago, Ind. It is expected that the Lake Charles fluid hydroformer will handle up to 30,000 BPD of naphtha.

Fluid hydroforming is said to have advantages of reduced investment and operating costs, better control due to being a truly continuous process, heat economy through inter-exchange, higher octane "ceilings," greater flexibility with regard to feed stocks, higher gasoline yields, and others.

Presented here are the most recent results obtained in the operation of a fluid hydroforming pilot plant. Experimental data are presented on the effect of temperature, pressure, tail gas recycle, precatalytic thermal reforming, and the result of catalyst life tests.

Also included is the application of fluid hydroforming for the production of blending components for 115/145 grade aviation gasoline, and a discussion of fluid hydroforming economics. This paper was originally presented before the annual meeting of the South Texas Section, American Institute of Chemical Engineers, Galveston, October 19, 1951.

IN 1950 gasoline production in this country was at the rate of nearly 3 million barrels per day. The distribution of gasoline is shown in Table 1. It may be seen that 41 percent of the total gasoline was either natural or straight run, that 34 percent was obtained by thermal processing various fractions from crude oil, and 25 percent was catalytic gasoline. A large portion of the straight run is of low quality and the fraction of the thermal gasoline boiling above 250° or 300° F. is likewise of low octane. In other words one million barrels per day is of poor quality and therefore is available for some form of catalytic upgrading.

TABLE 1
Gasoline Distribution 1950

	Percent
Natural	8
Straight Run	33
Thermal	34
Catalytic	25
	100

For many years thermal processing was the only method used for naphtna upgrading. During the middle 30's the desulfurization and dehydrogenation reactions were being studied with gel type catalysts in industrial and university laboratories. The objectives were two-fold: first to remove corrosive sulfur which reduced markedly the lead response of gasoline and increased refinery maintenance and second to produce olefins which had been shown previously to have better antiknock properties than paraffins. So much hydrogen was produced in experiments with such catalysts as chromium oxide gel and molybdenum oxide that these investigators were prompted to look for aromatics in the product. Aromatics were found to be there in high concentration. Olefins were present in low concentration. The catalysts deactivated quickly due to excessive carbon or coke deposition. To make the process commercially attractive it was necessary to recycle tail gas rich in hydrogen and increase the pressure to such a point that the catalyst could be used for a considerable time, e.g., hours rather than minutes without excessive carbon formation and gas production. With the discovery of the effect of operation

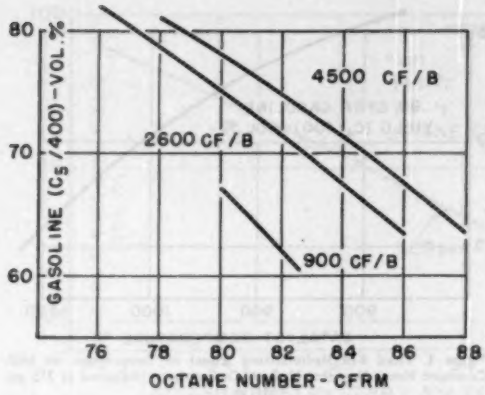


Figure 2. Fixed Bed Hydroforming of East Texas Light Naphtha. Effect of Circulating Gas Rate. MoO_3-Al_2O_3 Catalyst—200 psi.

under substantial H_2 pressure the hydroforming process was born!

Eight fixed-bed hydroformers were built before and during World War II. The first was a two-reactor unit of 7500 bpd capacity for Pan-Am at Texas City. This unit went on stream in 1940. Subsequent units were built for Humble Oil & Refining Company, Continental Oil Company, Union Oil Company of California, The Texas Company, Standard Oil Company (Indiana), The Pure Oil Company, and Standard Oil Company of California. These plants—with the exception of Union's—were four-reactor units. Two reactors with intermediate reheat were employed in series on reaction while two were regenerating, purging, etc. The largest fixed-bed hydroformer was Humble's which was designed for a normal throughput of 16,500 bpd and subsequently altered for a throughput of about 25,000 bpd. During the war the hydroformers produced nitration grade toluene and aromatic blending agents.

Chemical Reactions & Equilibria

Feed stock composition is of considerable significance in hydroforming. The more naphthenic stocks, especially those in which cyclohexane homologs predominate, will give the best yield-octane relationships and the highest aromatic yields. Typical fixed-bed pilot plant data for Hastings, East Texas, and West Texas heavy naphthas are shown in Table 2. The yields of 10-pound RVP 400° F. e.p. gasoline of 95 Research octane clear were 92.4 percent for Hastings, 86.4 for East Texas and 85.7 for West Texas. The Hastings stock contained the highest naphthene content (about 63 percent) and gave the best results. The East Texas and West Texas heavy naphthas contained approximately 35 percent and 30 percent naphthenes, respectively.

The various reactions that take place in hydroforming do not all occur at the same rate. For example, C_6 ring naphthene dehydrogenation proceeds very rapidly, whereas the conversion of paraffins to aromatics is very much slower. Likewise, side reactions with C_6 ring naphthenes are almost negligible, whereas such is not the case with paraffins.

Several reactions occurring in hydroforming are presented in the next three tables:

(a) In Table 3 reactions of naphthenes containing 5 and 6 carbon membered ring compounds are shown. The conversion of DMCH to xylene and DMCP to toluene are typical.

(b) In Table 4 reactions of paraffins are shown. The first reaction shown is dehydrocyclization of normal octane to ethyl benzene.

TABLE 2
Fixed Bed Hydroforming
MoO_3-Al_2O_3 Catalyst
95 CFRR Octane, 10 Lb. RVP

Feed Source	Boiling Range	Yield (400 EP) Volume Percent
Hastings	272/407	92.4
East Texas	248/396	86.4
West Texas	244/408	85.7

The second shows cracking of a normal paraffin (C_{11}) in the presence of hydrogen to form saturated hydrocarbons—propane and octane.

The third shows isomerization of paraffins—n-pentane to isopentane. The pentane fraction produced in hydroforming will normally contain approximately 60 percent isopentane.

(e) In Table 5 the reaction of a ring sulfur compound (a thiophene) is shown. The thiophene compound in this case is shown reacting with molybdenum in the presence of hydrogen. Whether the sulfur is eliminated as a metal sulfide, as is shown here, and burned off during regeneration of the catalyst, or is eliminated directly as H_2S during the reaction period depends on pressure, catalyst and catalyst holding time.

The extent to which the various reactions occur is a function of operating conditions, feed stock, and condition of catalyst.

Table 6 shows the equilibrium conversion of normal hexane, methylcyclopentane and cyclohexane to benzene at hydrogen partial pressures of 40 atmospheres (about 600 pounds) and 10 atmospheres (135 pounds gage).

TABLE 3
Reactions of Naphthenes in Hydroforming

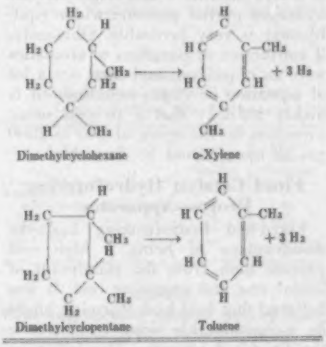
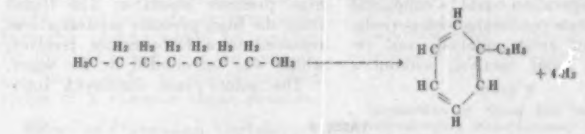


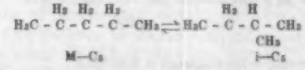
TABLE 4
Reactions of Paraffins in Hydroforming



N-Octane → Ethylbenzene

$nC_{11}H_{24} + H_2 \longrightarrow C_3H_8 + nC_8H_{18}$

$N-C_{11}$ → Propane + Octane



$M-C_5$ ⇌ $i-C_5$

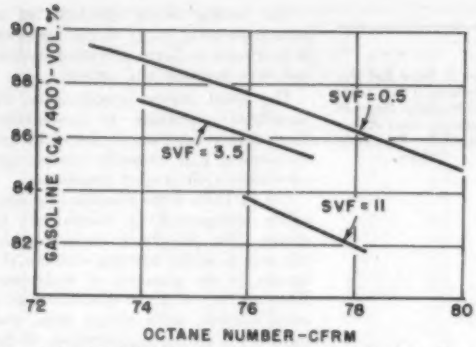


Figure 3. Fixed Bed Hydroforming of East Texas Light Naphtha. Effect of Thermal Reforming in Preheater.

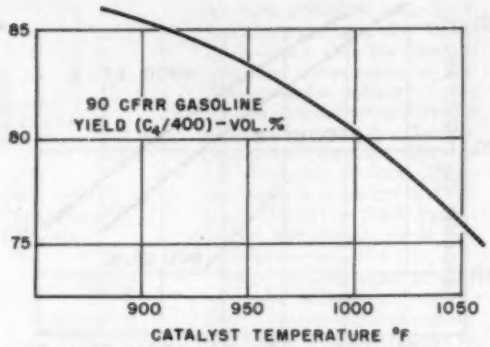


Figure 4. Fixed Bed Hydroforming. Effect of Temperature on Mid-Continent Heavy Naphtha. MoO_3-Al_2O_3 Catalysts. (Adjusted to 315 psi. H_2 pp.)

Equilibrium conversion to benzene at 40 atmospheres is only 3 percent for normal hexane, 40 percent for methylcyclopentane and 84 percent for cyclohexane. On the other hand, when a hydrogen partial pressure of 10 atmospheres is employed, equilibrium conversion to benzene for normal hexane is 86 percent, for methylcyclopentane 95 percent, and for cyclohexane 99+ percent. Examination of these thermodynamic data shows the advantage of fluid hydroforming over certain competitive processes lies in the fact that the former process may be operated at severe conditions and relatively low hydrogen partial pressure where equilibrium is very favorable. Obviously, if conversion of paraffins to aromatics were an objective—and there are a lot of paraffins in virgin naphthas—it is highly unlikely that a process using pressures on the order of 600 to 1000 psi or more would be desirable!

Fluid Catalyst Hydroforming Process-Apparatus

Fixed-bed hydroforming had the disadvantage of being a high cost process both from the standpoint of initial cost and operating cost. It was believed that fluid hydroforming might be a considerable improvement over the fixed-bed process. The following incentives existed for its development:

1) Investment and operating costs would probably be greatly reduced.

2) The operation could be conducted at steady state conditions with periodic addition of fresh catalyst, and removal of spent catalyst, without a shutdown.

3) The catalyst life would probably be longer due to better temperature control during regeneration.

4) The complicated time cycle control system could be eliminated.

5) The multiple reactor system could probably be eliminated. The reactor would not have to be designed for regeneration as well as reaction.

6) The reaction could be operated isothermally which type of operation was demonstrated to be superior from a selectivity standpoint.

7) Regeneration technique could be greatly simplified, easier to control, and cheaper to carry out.

8) Utilization of catalyst would be more efficient. Channeling has sometimes been experienced in fixed-bed plants resulting in a portion of the catalyst bed becoming ineffective. Trouble has sometimes been experienced during regeneration due to channeling.

A flow-sheet for a 3-bpd fluid hydroforming pilot plant is shown in Figure 1. The flow through the reaction system was as follows:

The feed naphtha in admixture with recycle gas was pumped through a preheater to the bottom of the reactor which was 45 feet long and about 3 inches in diameter. The reactor effluent passed through porous stainless steel filters, at the top of the reactor, to a condenser, and then to the high pressure separator. The liquid from the high pressure separator was removed to a low-pressure receiver, which was surrounded by ice water.

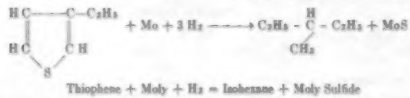
The pilot plant employed intermittent rather than continuous catalyst transfer from reactor to regenerator, because of the difficulties involved on this scale in circulating the small flows of catalyst required. At regular intervals, a portion of the spent carbonized catalyst was withdrawn from reactor, and replaced with regenerated catalyst. The third vessel, shaped like the reactor and regenerator, was used for storage of regenerated catalyst.

The flow through the regeneration system was as follows: Filtered air was compressed, metered, and subsequently passed to a control valve. This flow control valve was arranged to control the air rate in a given ratio to the recycle flue gas or nitrogen. It then was preheated, and entered the bottom of the regenerator. Flue gas left the top of regenerator, through porous stainless steel filters, to a pressure control valve. From this point, the flue gas could be vented, as shown on the flow-sheet for nitrogen-air once-through operation, or recycled.

In the fixed-bed process the regeneration part of the plant represented about 40 percent of the investment. It was necessary to keep the O_2 concentration of the inlet gas down to about 2 percent. This entailed a tremendous quantity of expensive flue gas recycling. Using this pilot plant, the catalyst has been regenerated successfully time and again with undiluted air at high pressure by charging air to a mixture of carbonized and uncarbonized catalyst. The importance of

TABLE 5

Thiophene Desulfurization in Hydroforming



Thiophene + Moly + H_2 = Isohexane + Moly Sulfide

TABLE 6

Thermodynamic Data—900° F.

Compound	pp H_2 Atm.	Equil. Conv. to Aromatics
n-Hexane	40	2%
Methylcyclopentane	40	40%
Cyclohexane	40	84%
n-Hexane	10	86%
Methylcyclopentane	10	95%
Cyclohexane	10	99+%

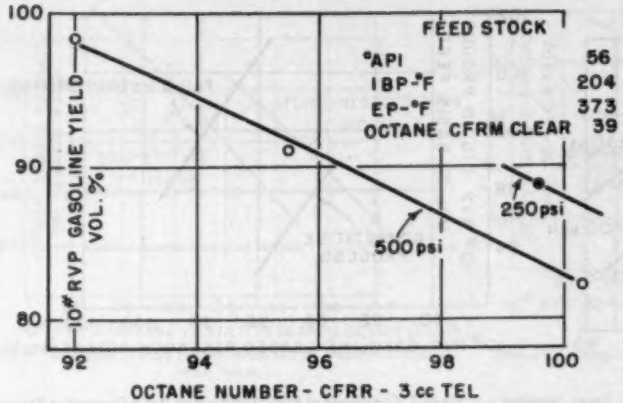


Figure 5. Fluid Hydroforming of Mid-Continent Heavy Naphtha. Kellogg MoO_3-Al_2O_3 Gel Catalyst Yield vs. Octane.

being able to regenerate with straight air is obvious.

The Catalyst

In the selection of a catalyst one of the chief considerations was to find one that was capable of synthesizing aromatics from paraffins and olefins as well as from naphthenes. It was reasoned that the hydrogenation-dehydrogenation oxide type catalysts, such as molybdenum and chromium oxide might possess suitable activity at temperatures well below those employed in thermal reforming. Initially tests were conducted in glass equipment at atmospheric pressure. It was discovered that a rugged catalyst could be made if the Group VI metal oxide were deposited on a support. The best support found for this reaction was alumina. Interestingly enough, the chromium catalyst, which showed a marked superiority over molybdenum at atmospheric pressure, for dehydrocyclization of n-heptane, was inferior to the latter catalyst under substantial hydrogen partial pressure; consequently, the molybdena-alumina catalyst was used for hydroforming. The first commercial catalyst was made by impregnating a material, very similar to "activated alumina," with a molybdenum salt solution followed by drying and calcining at a temperature above 1000° F.

Ultimately a catalyst comprising alumina gel as a support was used by most of the operators of fixed-bed hydroformers. For the development of fluid hydroforming one of the catalysts that has been used in the 3-bpd pilot plant consisted of molybdena on a silica-stabilized alumina gel. Particle size distribution of the catalyst before being placed in the fluid hydroformer and after six weeks operation is shown in Table 7. In six weeks' time, in a completely closed system, the 0-20 micron fraction only increased from 3 percent to 12 percent. Apparently the catalyst has good attrition resistance.

In the fluid hydroforming experiments conducted in the laboratory pilot plant no decline in catalyst activity has been observed. This is shown in Table 8 where the original fluid hydroformer charge is compared with catalyst that had been in use for 895 hours. The activity checks were made at a pressure of 400 psi and a temperature of 930° F. In a small fixed-bed test unit the product quality was 82.3 octane CFRM before use and 83.1 after use.

A large volume of data has been compiled from the fluid hydroforming pilot plant just described. These data show definite improvement over fixed-bed hydroforming from a yield standpoint. On Table 9, a yield comparison has been made for operation on 406° and 425° F. e.p. Mid-Continent heavy naphthas. It can be seen that fluid hydroforming gave 2.3 volume percent higher gasoline yields than the conventional process when producing 90 clear Research octane gasoline. This comparison is based on 100 percent C_4 recovery gasolines. Since the gasoline from the fluid operation was of lower vapor pressure an even more favorable picture would be possible for the fluid operation if the comparison were made on liquid product yields of a common vapor pressure.

Effect of Operating Variables

Several of the following tables and curves demonstrate the profound effect of certain operating variables.

The importance of employing tail gas recycle for this process is shown in Figure 2 for some fixed-bed data obtained on an East Texas light naphtha many years ago. A MoO_3-Al_2O_3 catalyst was used in this program. The relationship between debutanized gasoline yield and CFRM octane number with circulating gas rate as the parameter is presented. The debutanized gasoline yield at 82 octane (motor) increased from 62 percent at 900 cubic feet per barrel to about 72 percent at 2600 cubic feet per barrel and further to 75 percent at 4500 cubic feet per barrel.

The effect of thermal reforming prior to the catalyst bed is shown in Figure 3. This soaking factor is used as the criterion for determining the extent of thermal reforming. Soaking volume factor is defined as the cubic feet of furnace volume above 800° F. divided by the barrels per day of cold naphtha charged times the mean reaction rate in the preheater, transfer line, and empty space before the reaction mixture reaches the catalyst relative to a base temperature of 800° F. These experiments were made at a pressure of 200 psi and the catalyst contained MoO_3 as the active ingredient. The 100 percent C_4 recovery gasoline yield at 78 octane (motor) increased from 82 volume percent at a soaking volume factor of 11 to 86.3 volume percent at a soaking volume factor of 0.5. Thermal reforming of the naphtha in the fluid process is reduced over the fixed-bed process since the large distribution space above the

TABLE 7
Fluid Hydroforming
Kellogg MoO_3-Al_2O_3 Gel Catalyst
Typical Particle Size Analyses

	Charge Catalyst	After 6 Weeks Operation
Keller Analysis		
0-20 Microns—Wt. percent	3	12
20-40	14	17
40-60	44	47
60+	39	24

TABLE 8
Fluid Hydroforming Catalyst Activity Tests

	Original Fluid Hydroformer Charge	After 895 Hours of Operation in Fluid Hydroformer
Pressure—psig	400	
Temperature—°F	930	
Gasoline Inspections C_4/400		
Gasoline Octane—CFRM	82.3	83.1

TABLE 9
Comparison of Fixed Bed and Fluid Hydroforming Mid-Continent Naphtha

	Fixed Bed	Fluid Bed
Feed—Gravity, °API	50.1	52.7
ASTM Boiling Range, °F	203/406	208/425
Aniline Point, °F	136	137
Octane, CFRR	34	36
Gasoline (C_4/400)		
Octane, CFRR	90	90
Yield, Volume Percent	79.6	81.9

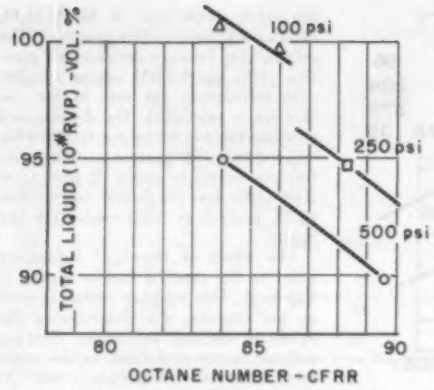


Figure 6. Fluid Hydroforming 200/344° F. West Texas Naphtha. Kellogg Gel Catalyst. Effect of Pressure.

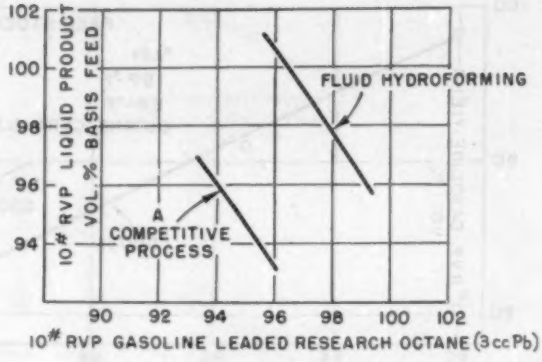


Figure 7. Comparison of Fluid Hydroforming and a Competitive Process—East Texas, Coastal.

catalyst is eliminated. In the fluid bed the reacting vapors are distributed by the catalyst.

The importance of temperature on the catalyst selectivity as indicated by gasoline yield is presented on Figure 4. The data were obtained in a fixed-bed pilot plant operating with a MoO_3-Al_2O_3 catalyst. All the results were first adjusted to a common hydrogen partial pressure—in this case 315 psi—and to the same octane—90 Research. At 1050° F. the yield was 76 volume percent; at 1000° F., 80 percent; at 950° F., 83 percent, and at 900° F., 85.5 percent. It is apparent that as the temperature was decreased the yield of gasoline of a given quality increased.

The fluid hydroforming pilot plant has been operated to obtain a liquid product containing hardly any material boiling above 400° F. by use of a feed stock with an end point somewhat below 400° F. Yields from a 39 (motor) octane 204/373° F. Mid-Continent heavy naphtha—where the liquid is substantially all 400 e.p. gasoline—are superior to those previously shown for a 425° F. end-point feed stock. Figure 5 illustrates graphically the relationship between 10-pound RVP gasoline yield and leaded research octane. At 500 psi a yield of 83 volume percent of 100 leaded Research octane was obtained, while at 250 psi this yield increased to 88 volume percent of 100 leaded Research octane gasoline.

On Table 10 summarized data are presented for experiments at 100 and 250 psi, operating on a West Texas naphtha. A molybdena-alumina gel catalyst was used. The feed stock had a boiling range of 200°-344° F. and a sulfur content of 0.23. Operating temperature ranged from 896° to 944° F. At 100 psi and at 97 leaded Research octane the 10-pound RVP liquid yield was 99.7 volume percent; at 95.6 leaded Research the 10-pound liquid yield was 100.7 volume percent.

The importance of pressure is further illustrated by Figure 6. When fluid hydroforming the 200°-344° F. West Texas naphtha the yield of 87 Research octane gasoline (10-pound RVP) increased from 92.5 percent at 500 psi, to 96 percent at 250 psi and to 98.5 percent at 100 psi.

TABLE 10

Fluid Hydroforming With MoO_3-Al_2O_3 Catalyst 200/344° F. West Texas Naphtha

Operating Conditions			
Pressure—psig.	250	100	100
Temperature, °F.	944	899	896
Yields On Feed			
Total Liquid (10 lb. RVP) Volume Percent	94.5	99.7	100.7
Gasoline Inspections			
Basis 10 lb. RVP Gasoline			
Octane—CFRR	85.5	85.9	83.9
CFRR + 3 cc TEL	98.5	97.1	95.6

TABLE 11

Fluid Hydroforming High Sulfur California Cracked Naphtha (142/384° F.)

Catalyst	MoO_3-Al_2O_3
Operating Conditions	
Temperature, °F.	938
Pressure, psig.	100
Product Distribution	
10 lb. RVP, Liquid Product—Vol. percent	97.0
Extraneous C_4 (For 10 lb. RVP.)—Vol. %	6.2
Dry Gas—Weight Percent	5.8
Carbon—Weight Percent	1.8
Sulfur Removed—Weight Percent	0.90
Gasoline Inspections	
Reid Vapor Pressure—psi.	10
Octane Number—CFRR	84.4
CFRR + 3 cc TEL	95.7
Sulfur—Weight Percent	0.01

Fluid Hydroforming Cracked Naphtha

On Table 11 results for simultaneous hydroforming and desulfurizing a high sulfur California cracked naphtha are shown. The boiling range of the feed stock was 142°-384° F. and the sulfur content of the feed, 0.91 weight percent. The operating conditions were 938° F. and 100 psi with a MoO_3-Al_2O_3 stabilized gel catalyst. The 10-pound RVP liquid product yield was 97 volume percent. This material contained 6.2 percent extraneous butanes which were required to bring the RVP up to 10 pounds. The clear Research octane was 83.3 on the 100 percent C_4 recovery gasoline and the leaded Research octane 94.4. The leaded Research octane of the 10-pound RVP gasoline was 95.7. The sulfur content of the gasoline was 0.01 weight percent.

Fluid Hydroforming for Aviation Gasoline

Fluid catalyst process data shown in Table 12 have also been obtained for the production of high aromatics yields for aromatic blending components for 115/145 grade aviation gasoline. A 200°-300° F. (true boiling point) fraction from a mixed crude source was used as the feed stock. The test was conducted at a pressure of 250 psi and a temperature of 934° F. The total liquid yield (C_4 and heavier) was 83 volume percent. The isobutane

TABLE 12

Fluid Hydroforming For Aromatics or 115/145 Grade Aviation Gasoline 214/291° F. Virgin Naphtha

Operating Conditions	
Pressure—psig.	250
Temperature—°F.	934
Yields on Feed	
100 percent C_4 Liquid—Volume Percent	83.0
C_4 Fraction—Volume Percent	6.9
Butenes	0.1
Isobutane	2.9
n-Butane	3.9
C_5 Fraction—Volume Percent	7.2
Isopentane	3.8
n-Pentane	3.4
Depentanized Liquid—Volume Percent	88.9
Pre-Aviation Blending Agent—Volume Percent	22.8
Aviation Blending Agent—Volume Percent	33.5
Post-Aviation Blending Agent—Volume Percent	12.6
Carbon—Weight Percent	0.37
Hydrogen Produced—CF/B.	740

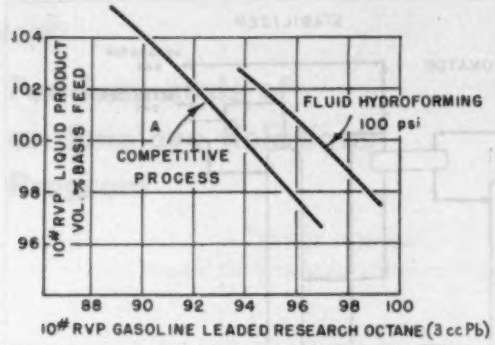


Figure 8. Comparison of Fluid Hydroforming and a Competitive Process—West Texas.

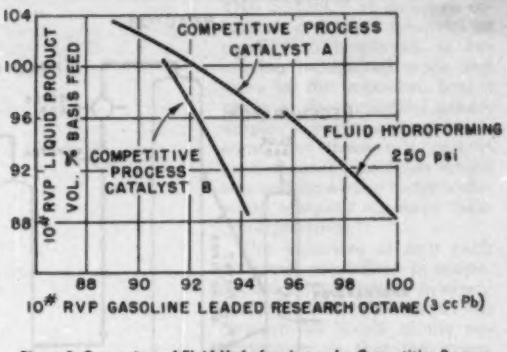


Figure 9. Comparison of Fluid Hydroforming and a Competitive Process—Mid-Continent.

yield was 2.9 volume percent and the n-butane, 3.9 percent. The isopentane yield was 3.8 volume percent and the n-pentane yield, 3.4 percent. The depentanized liquid product was fractionated into three cuts called pre-aviation, aviation, and post-aviation blending agents. The yields of these three products were 22.8, 33.5, and 12.6 volume percent, respectively. The carbon production was only 0.37 weight percent basis feed. Hydrogen production was 740 cubic feet per barrel.

In Table 13 inspections for the various products on the previous table are shown. The debutanized liquid rated 95.2 Research octane clear. The pre-aviation blending agent had a Research octane of 91.8 with 3 cc. of lead. The aviation blending agent had an F-3 blending octane number (1-C) of 100 and an F-4 blending index number (3-C) of 216. The clear Research octane number of the post-aviation fraction was greater than 100 CFRR.

TABLE 13

Fluid Hydroforming for Aromatics or 115/145 Grade Aviation Gasoline

Inspections of Products	
Debutanized Liquid	
Octane Number—CFRR	95.2
Pre-Aviation Blending Agent	
Octane Number—CFRR + 3 cc TEL	91.8
Aviation Blending Agent	
Reid Vapor Pressure—psi.	0.4
Blending Octane Number—F-3 + 4.6 cc TEL	100
Blending Index Number—F-4 + 4.6 cc TEL	216
Post-Aviation Blending Agent	
Reid Vapor Pressure—psi.	0.5
Octane Number—CFRR	>100

TABLE 14

Fluid Hydroforming Economics 7500 BPD Unit

	Unit Cost	BPD	$/Day
Credits			
10 lb. RVP, Gasoline/Barrel	$5.04	6900	34803
Fuel Gas (FOE)/Barrel	1.90	803	1525
Total Credits	....	....	36328
Debits			
Stock Cost			
Naphtha/Barrel	3.36	7500	25200
Extraneous Butanes/Barrel	2.42	300	726
Direct Operating Cost			
Total Process Costs	....	....	1868
Ethylizing, Cents/cc TEL/Gal.	.02	....	1713
Taxes, Insurance and Royalties	....	....	865
Total Debits (Before Depreciation)	....	....	30092
Credits Less Debits	....	....	6233
Investment—Dollars		$2,230,000	
Payout Time—Years		0.99	

Comparison with a Competitive Process

In order to illustrate how fluid hydroforming compares with a competitive process a series of figures has been prepared in which pilot plant data for fluid hydroforming are compared with published pilot plant data for a competitive process. Feed stocks used in the comparisons were not identical, but are generally quite close in important properties.

In Figure 7 fluid hydroforming results on an East Texas stock are compared with published results of another process on a coastal naphtha. Feed stock inspections are compared in Table A. At 96 leaded Research octane (3 cc. TEL) the yield differential in favor of the fluid process is 7.4 volume percent. The comparison is based on 10-pound RVP liquid product. Where insufficient C_4's were made for a 10-pound RVP product, extraneous C_4's were added.

In Figure 8 fluid hydroforming results on West Texas naphtha are compared with published results on another process on a West Texas-Wyoming blend. Feed stock inspections are compared in Table B. At 96 leaded Research octane (3 cc.) the yield differential in favor of the fluid process is 3 volume percent. As in the previous comparison yields of 10-pound RVP liquid product are shown.

In Figure 9 fluid hydroforming results on a Mid-Continent naphtha are compared with those for a competitive process on a similar stock. Feed stock inspections are compared in Table C. Results for two catalysts designated Catalyst A and Catalyst B were presented for the competitive process. It is necessary to extrapolate the fluid hydroforming results back down in octane in order to make a comparison at 94 leaded Research octane. The yield differential in favor of fluid hydroforming is about 1 percent when compared with Catalyst A for the other process and 9 percent when compared with Catalyst B. In most cases extraneous butanes were required to bring the vapor pressure of the fluid hydroformate up to 10-pound RVP. This is normally a distinct advantage for the process. Generally speaking fluid hy-

TABLE A

Feed Source	Fluid Hydroforming Predominantly East Texas	Competitive Process Gulf Coast
Gravity—°API	53.9	57.6
ASTM Dist.		
IBP—°F.	218	132
EP—°F.	355	309
Octane—CFRR	53.3	54.6

TABLE B

Feed Source	Fluid Hydroforming West Texas	Competitive Process West Texas-Wyoming
Gravity—°API	51.9	52.0
IBP—°F.	200	150
10 percent	245	214
50 percent	280	289
90 percent	314	350
EP—°F.	344	381
Octane—CFRR	51.2	49.0
Sulfur—Weight percent	0.22	0.26

TABLE C

Feed Source	Mid-Continent	
	Fluid Hydroforming	Competitive Process
Gravity—°API	56.1	
IBP—°F.	204	230
EP—°F.	373	395
Octane Number—CFRR	40.9	35.0

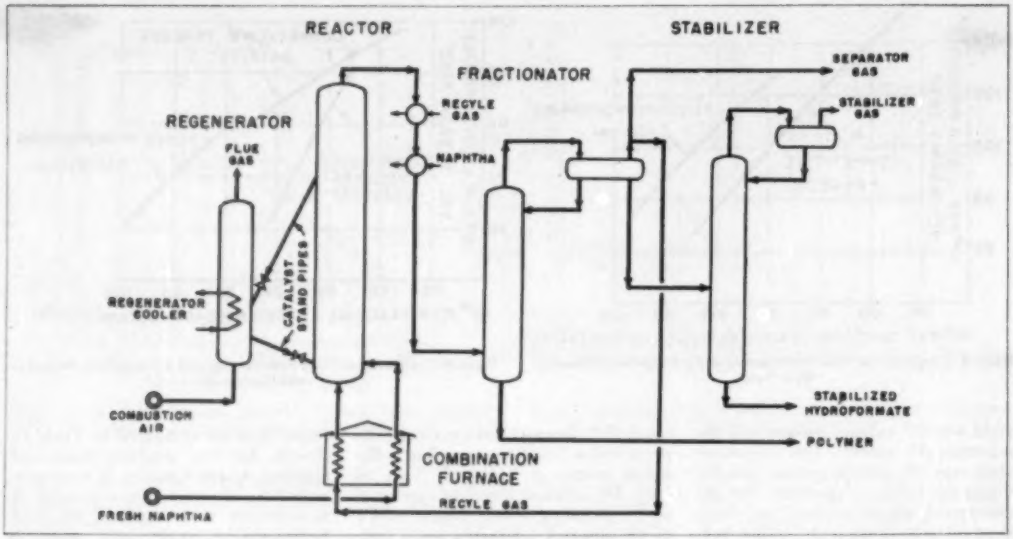


Figure 10. Fluid Catalytic Hydroforming Unit.

droforming was operated at such conditions that a lower volatility liquid product of a given octane number was obtained from the fluid process.

A flow-sheet for a commercial plant is shown in Figure 10. Naphtha and recycle gas are preheated separately. The recycle gas is charged to the bottom of the reactor and the naphtha a little higher up. Spent catalyst flows down through a standpipe into the regenerator. Regenerated catalyst flows down through another standpipe, at a controlled rate, into a low point in the reactor. Spent catalyst is regenerated with air—straight air—and the regenerator is maintained at a constant temperature by a cooler installed in the regenerator. The recovery system is more or less conventional and requires no explanation.

Fluid Hydroforming Economics

The economics of fluid hydroforming represent a considerable improvement over the fixed-bed process. This is attributed to reduced investment and operating costs in addition to the improved yield picture.

On Table 14 an economic balance sheet for a 7500-barrel-per-day fluid hydroformer is presented. The feed stock used in this estimate was a Mid-Continent heavy naphtha. It had an ASTM boiling range of 204/373° F., and a Research octane number of 39. The motor gasoline had a 10-pound RVP and a Research octane rating of 95 + 3 cc TEL. The gasoline was assumed to be worth 12 cents per gallon and the feed stock 8 cents per gallon. Extraneous butanes were valued at 5¾ cents per gallon. Total credits were $36,325 per day and total debits (before depreciation), $30,092 per day. This left a credit less debit of $6,233 per day. The cost of the 7500-bpd plant was estimated at $2,250,000. Hence, a payout time of one year is indicated. In this calculation of gasoline yield representing 94-95 percent of that observed in the laboratory was used. If the calculation had been based on the laboratory data the payout would be about 0.88 years.

Summary

To summarize, fluid hydroforming offers the following advantages:

1) Considerably reduced investment and operating costs. This has been brought about through elimination of alternate reactors with their attendant complicated piping and time-cycle controllers, decreased compression costs, lower carbon-burning costs, and elimination of reheat furnaces.

2) It is a truly continuous process, since catalyst activity can be maintained at a constant level indefinitely by periodic additions of fresh catalyst if activity declines with age.

3) A portion of the heat produced in the regeneration may be used to supply endothermic reaction heat, thus reducing preheater duty and thermal cracking in the preheater. "Pre-cracking" of the naphtha is further reduced over fixed-bed practice since the large distribution space above the catalyst is eliminated.

4) The process has a very high octane "ceiling." Debutanized gasolines of over 95 Research clear octane have been produced with attendant carbon yields of less than 0.5 percent. Such octane numbers come about largely due to the ability of the process to produce higher aromatics yields than any known petroleum process. Excellent yields of aromatic blending agent for 115/145 grade aviation gasoline result from such high octane operation.

5) Greater flexibility with regard to feed stocks. Feed stocks ranging from C_6 cuts (for benzene production) to kerosine can be employed if desired. The pilot plant has been employed to upgrade numerous virgin heavy naphthas, kerosine, and high-sulfur cracked naphtha.

6) Higher gasoline yields. Isothermal operation and elimination of "channeling" result in better activity and selectivity of catalyst than is possible in present "fixed-bed" units.

7) Use of a circulating catalyst stream affords an additional process tool which can be used not only to aid in temperature control but also as an aid to catalyst activity and selectivity.

8) Catalyst level in the reactor can be varied over wide limits to increase the flexibility of the unit if feed stocks or catalysts other than those used for design purposes are employed.

9) Since it is a regenerative process, the operating conditions can be varied over a wide range and suited to a wide variety of feed stock.

ACKNOWLEDGMENT

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* * *

Fundamentals of an Employe Relations Program

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THE SUBJECT of employe relations, or human relations as applied to employes, is becoming recognized more and more for the important part it plays in the industrial scene. Employe relations is not a science, but there are certain fundamental principles which can be followed in order to develop a sound employe relations program.

The objective of any such program, regardless of scope, should be to promote in every possible way cooperation through all levels of the organization so that the maximum amount of efficient work can be accomplished with the greatest individual personal satisfaction to employes. This paper was presented before the Southern Regional Meeting of the Natural Gasoline Association of America, Tyler, Texas, October 19, 1951.

OUT in the oil fields in the early days, there was an independent pioneering spirit among oil field workers. A great deal of the field work in those days—the drilling of wells, the laying of pipe lines and the construction of gasoline plants—was performed by independent contractors or operators who maintained close contact with their employes. These employers, although rough in speech and dress, usually were most generous with their crews, and because of their generosity and democratic attitude, employes possessed a strong sense of loyalty. It was not uncommon for bonuses to be paid when work was completed in record time, for Christmas presents to be distributed or for barbecues or other celebrations to be put on by the contractors. This close relationship between employers and their men brought about a sense of belonging and a feeling among employes that extra work and effort would not be forgotten and that compensation in some form would be forthcoming.

In recent years much of this freedom of action on the part of an employer in his relations with his employes has been curtailed by legislation. In spite of the fact that much of the legislation may have improved the economic status of employes in some industries, it has nevertheless diminished the satisfactions enjoyed by many employers in helping deserving employes, and by employes in being rewarded for extra effort. The inevitable result of this social legislation has been the deterioration of the fine relationship that existed in many organizations; the insistence by employe groups on the one hand for everything that the law provides and an unwillingness on the part of some employers on the other hand to do any more than is required by law. Thus, there has been a substitution of a sort of legal arms-length relationship for the old loyalty and sense of belonging that was shared by many employers and employes. In many ways this has not been good for either management or employes and, although many advocates of present social legislation credit the shortsightedness of industry management for bringing about such regulations, the author cannot help but feel that somehow they forget that employes are more interested in a number of things other than a legal limit on the number of hours of work, a minimum rate of pay, and the right of collective bargaining. Opinion surveys indicate that employes rank a sense of belonging, opportunity and individual dignity ahead of these more material satisfactions. We know that legislation cannot provide these important intangibles any more than it can force upon employes loyalty, group spirit and a desire to improve production.

Assuming every employer desires a loyal group of employes, he must recognize the fact that he is in competition for this loyalty with two powerful influential groups: politicians who promise employes Utopia through more legislation, and organized labor who promises security, better pay and better working conditions. Under these conditions, establishing, building and retaining the loyalty of employes offers many difficulties. There is strong evidence, however, that employes prefer their first loyalty to be to their employer and those managements who have been unwilling in the face of this competition to shift to others what is rightly their own responsibility for good employe relations have in the main retained loyal, efficient organizations.

With this brief review of some of the changes affecting the general climate existing today in the area of industrial relations, let us review some of the very basic fundamentals of a sound employe relations program. The objective of any such program regardless of scope should be to promote in every possible way cooperation through all levels of the organization so that the maximum amount of efficient work can be accomplished with the greatest individual personal satisfaction to employes.

There are numerous approaches to this objective and, regardless of the techniques employed, its ultimate success depends upon employe acceptance. Because the attitudes of people come out of their everyday experiences, these attitudes are not static but are undergoing continual change, and what appears to be a good technique in one company may be disastrous in another. Let us not, therefore, dwell on the many techniques employed in the employe relations field other than to caution that the many services and gadgets advertised as sure cure for labor troubles, poor morale and low productivity, should be carefully examined in the light of existing conditions in one's own organization. Although many of these services are helpful if properly used under favorable conditions, it is fundamental that good employe relations, like good family relations, must start at home and if maintained over a long period is the result of sincere effort on the part of the members of the group. Thus, the responsibility for maintaining good morale in an organization can not effectively be shifted from the shoulders of management.

After determining the objective of an employe relations program, the first consideration should be a *few simple basic statements of personnel policy*. In order for all employes, particularly supervisors, to have as uniform a conception of policy as possi-

ble, it is strongly suggested these basic policies be made available in written form. Although they may have been repeated many times by word of mouth, the fact that you are willing to publish and distribute them may help to convince employes of management's sincerity. Such policies should embody a sincere desire by management to be fair and frank with employes. Personnel policies born of expediency and not based on a sincere desire to adhere to sound principles of human conduct usually fail. Employes are apt to accept a policy, even though it may fall short of their expectations, if they are convinced of management's fair intent.

Consistency and Sincerity

Consistency as well as *sincerity* is extremely important in personnel policy decisions, for these decisions have an accumulative effect, and, therefore, before action is taken, thorough consideration must be given to the ability of management to continue the policy and the effect it will have on the organization in years to come. We would not wish to imply that policies should not change to meet changing conditions, for in a dynamic economy, because of technological and social advances, employe relations policy can become outmoded and obsolete and must give way to new approaches and methods just as plant equipment must continually change to meet new challenges. In many companies the new employe receives a handbook containing the company policy regarding employments, discharges, transfers, wages, promotions, benefits, service rules, working rules, safety rules, and other matter of mutual interest.

After a few simple forthright statements regarding management's personnel policy, the next logical fundamental designed to attain our objective is a system involving a recognition on the part of management that an employe should be permitted to advance within the organization according to his ability to contribute. Although the word *training* is not desirable because it implies a method of formal schooling, for want of a better term and because it is widely accepted in employe relations circles, we shall call this fundamental *training*. All organizations train people in some manner. Many have formal programs for supervisors, safety meetings for employes and conferences for higher management, all designed to present information, techniques and "know how" to assist employes in their growth with the company. Many have no formal programs but depend on each supervisor to train those under his supervision. The incentive to train employes must come from top management and be recognized as an integral part of a supervisory job. Employes have a right to know the duties and responsibilities of their job and what is expected of them in the way of performance.

Our next fundamental is *communications;* the exchange of information from management through levels of supervision down to employes and back up through supervisors to management. A successful business organization is like a football team except that here there are no substitutes on the bench. All are playing all the time and the contribution of each is important to the success of the others. If all members know the signals, each can understand how his job fits into the over-all objective, but like a football player, unless an employe knows the objective, his efforts may be worthless. The larger the organization the more difficult becomes the problem of communication because information must pass through so many people.

To demonstrate the difficulty of passing verbal information through several people, try making a simple statement to one person and ask him to pass this same statement in turn through several individuals. More often than not, the statement will be entirely changed when it reaches the last individual. The more people involved the greater the chance for misunderstanding. So it is in a business organization, the statements of top management may carry an entirely different meaning when they reach employe ears.

The most effective way to minimize grievances is to provide a strong, well-oiled communications system, for virtually all grievances can be traced to a misunderstanding on the part of someone. What may seem perfectly clear to you may be greatly misunderstood by someone else; for, even when we use every technique at our command to explain our thinking, because the English language is such an imperfect medium, it is extremely difficult to convey our true feeling and exact meaning to others. It is, therefore, important that we know how employes feel about policy decisions affecting them. Some companies have formal methods of testing employe reaction before decisions are made; some even go so far as to have an employe representative sit in on conferences and deliberations before decisions are reached. An alert management, with a strong feeling of team play existing through its supervisory groups, can tune its policies to the pulse of the organization without these extreme measures if the proper emphasis has been placed on the necessity of supervisors passing to top management not only employe reactions but recommendations concerning ways of improving morale. If the supervisor has the proper information very often areas of dissatisfaction can be eliminated before grievances become real.

Although letters, bulletins, house organs and other written material are helpful in communicating with employes, there is no substitute for personal contact. In personal discussions we tend to share the enthusiasm, the sincerity and the attitude of the speaker. Employes like to hear from the boss, they like to share his knowledge of future plans and past accomplishments of the organization, they like to feel he is a regular guy leading a crack team on which they play an important role. An executive is missing a really stimulating experience if he fails from time to time to talk sincerely with his men and let them share in his successes as well as his failures. If communications are good, supervisors tend to react favorably to top management decisions; if communications are bad, they become frustrated, insecure and lose their feeling of team play. This tends to demoralize employes working under them. Most employes want to share the viewpoint of a good management but unless they have been told management's thinking they can not share it.

Understanding Basic Economics

A great deal has been written recently about the need for employes to understand basic economics and the free enterprise system. The basic idea underlying our American institutions is that the supreme values are individual values and that institutions exist for the purpose of serving individuals. Our country, until recent years, has been one in which the employers had great influence. Their ideas on public policies were rather generally accepted. For a number of generations, in fact for over a century, employes in our economy have been becoming relatively more numerous. Today, nearly five out of six people who are working for a living in the United States are employes. The principal form of income of people today is the wage or salary. Today, there are still over 10 million self-employed people; however, latest available figures indicate there are over 60 million employed.

We are now a country whose voting population is made up predominantly of free employes. This change in working population has brought about a change in some of our national thinking and, where formerly the ideas, the philosophy, and the culture of the

country were in the main products of self-employment, within the last 17 years employes have become quite articulate. From now on they will have much to say about our governmental policies. Their ideas of what makes the economy "tick" and their ideas of right and wrong may not be the same as the ideas of the self-employed. Is it any wonder, therefore, in this new laboristic community, that we have had so many rapid changes in the field of social legislation? Under the self-employed philosophy a rapid increase in productivity and in the standard of living was achieved. It remains to be seen, if under this new laboristic philosophy, we will be able to maintain this rapid increase. The gains of technology have been going almost entirely to people in their capacity as employes rather than in their capacity as consumers; thus, with improved techniques, prices have not come down.

It is difficult to arouse employe interest in economics unless he can be shown how economic principles affect his pay check. The average employe reacts to facts in the same manner as management and yet there is a tendency on the part of management people to withhold facts and information from the very people who are paid good money to help them, and on whom they are so dependent in the conduct of their business. We need an enlightened employe group if we are to continue to raise our standard of living and if we are to have a better understanding of the basic economic truth that "to have more, we must produce more."

Importance of Timing

The next fundamental to be stressed is *timing in the matter of policy decisions*. If employe communications have been effective, management can usually sense the proper time to make certain personnel policy moves. Perhaps it is the practical experience gained from working in the field that causes me to feel that an employer is due some return from the money he spends for the benefit of his employes. A program providing pay for periods of disability, a policy providing for paid holidays, a policy providing for other so-called fringe benefits, represent costs in addition to the payroll and management has the right to expect a return for this added cost in loyalty, cooperation, increased productivity, improved morale and better employes.

Policy changes affecting these fringe benefits must be timed to gain the maximum return in these intangibles. If an otherwise obtainable policy decision is withheld until employes assume a belligerent attitude, the issuing of such a policy may come too late, thus, causing employes to feel management granted the concession only under pressure and not because of sincere interest in their welfare. Granting concessions under these conditions may cause employes to gain a false sense of their power to bring about changes which can result in serious trouble at the bargaining table.

In a like manner, a liberal, expensive policy may be sprung on employes without a real indication for its need and without proper explanation to employes of its intent. The result is very little return in improved morale and little effect on employe attitude. Often, what may seem a small inconsequential policy change, the cost of which is negligible, may bring a sincere employe response and produce a tremendous effect on employe morale.

In addition to *timing* and, coupled with it, is the fundamental of *procedure*. It is not always what you do, but how you do it that affects employe thinking. I have seen employes highly incensed over a policy which was instituted by management in a sincere desire to be generous. Most people, although outwardly glad to accept, inwardly resent a handout by their employer. They like to feel that as a result of loyal, productive teamwork and excellent management, their company can afford to adopt liberal policies. There is a great difference in saying to employes, "Because I have been financially successful and am a liberal man, I am going to give each of you a bonus this year," and saying, "Because we were fortunate enough to keep our plant running at full capacity and at the same time get a good price for our products and because of the fine work of our organization and the loyalty of each employe, our profits are such that each employe can have a two weeks' bonus this year." Note where the emphasis falls in the latter case. Employes like to feel they were a part of and contributed to this financial success.

Another irritant that can take all the employe relations value out of an otherwise excellent policy is the inclusion of unreasonable restrictions and qualifications in the policy. Here is where management is inclined to think it knows what is best for employes without realizing that, to be effective, it is far more important for the policy to receive employe acceptance. Why incur unnecessary employe criticism over minor restrictions on an otherwise excellent policy? It is important, therefore, when adopting a new policy or changing an existing policy, that the procedure used be designed to attain the maximum amount of employe good will.

There are many approaches to the management responsibility of promoting good employe morale. The effectiveness of a program designed to select good employes, a safety program, a benefits program or a medical program—none should be minimized. All of these contribute greatly to the promotion of good employe relations. Each of these subjects is worthy of a discussion in its own right, for in addition to morale value, they can contribute an actual monetary savings. Many operators, however, cannot justify the expense of a formal organization designed to carry out such programs and, for that reason, this discussion has dwelt upon a few fundamentals that can be applied in any organization, large or small.

Summary

1) Set down a few basic personnel policies in writing. Be sure they are clearly worded and are based on sound principles.

2) Give employes every opportunity to grow with your organization. Insist that supervisors recognize training as part of their job.

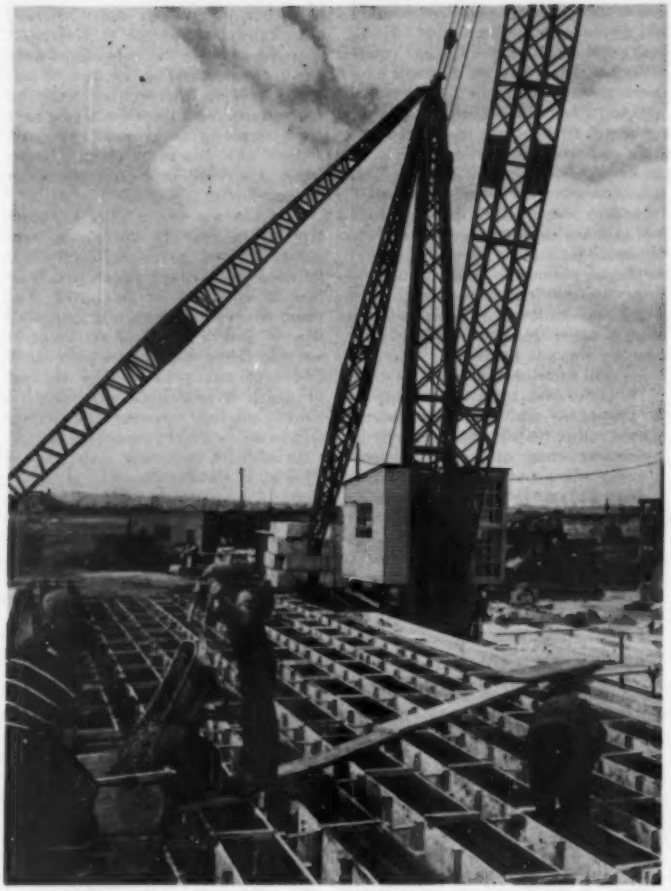
3) Communicate with your organization. Let them know how you feel about your business and encourage them to let you know how they feel. Never miss an opportunity to talk with your employes.

4) Time your policy changes to get the most return in employe good will.

5) Remember, it is not only what you do but how you do it. Try to adopt a procedure that will increase employe good will.

It is difficult to agree with people who try to present employe relations as a complicated conglomeration of science and techniques; who try to give activities in this field a cloak of super psychology. Boiled down to bedrock, it is a simple activity designed to help people work together in harmony. It isn't complicated and there is nothing mysterious about it. In fact, because it is just simple everyday living, we lose sight of our one objective; to promote in every possible way cooperation through all levels of the organization so that the maximum amount of efficient work can be accomplished with the greatest individual personal satisfaction to employes.

Any policy which, when evaluated in the light of this simple objective, does not measure up should be discarded. The little simple things in our everyday relationships with employes, both on and off the job, mean much in establishing the employe relations climate or morale we build into our organization.



Preparation of Shuttering and Pouring Concrete for Pre-Cast Piles, Coryton Project.

Coryton Marsh Tamed As Refinery Plans Develop

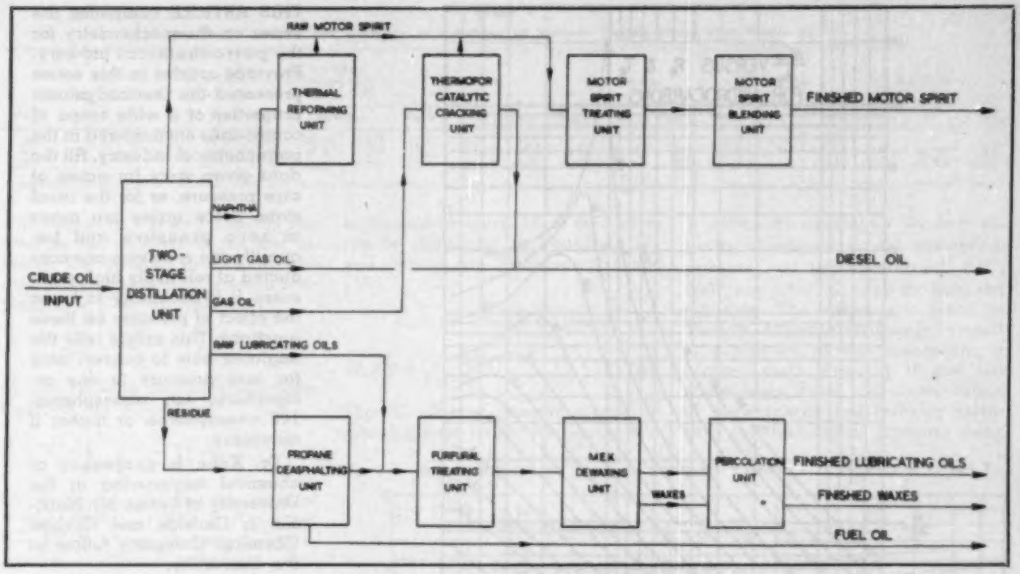
ONE of the few refineries in the world designed primarily for the manufacture of lubricating stock oils, the Coryton project, being developed by Socony-Vacuum Oil Company, Inc., and Powell Duffryn, Ltd., while progressing rapidly, has encountered tremendous difficulties in the form of low lying, partly waterlogged ground incapable of supporting any but small loads. At high tide the ground level is eight feet below that of the Thames river. Preparatory work on the site has involved placing more than half a million tons of gravel for site levelling, driving 10,000 piles 50 feet long, and pouring 40,000 tons of concrete for foundations.

Scheduled for completion in January, 1953, this project represents a substantial British-American capital investment of over $28 million. The refinery will process approximately 6 million barrels crude oil per year, and, by manufacturing products which are now largely imported, will effect a big saving in dollars for the United Kingdom. The refinery will manufacture high grade gasoline, diesel oils, fuel oil and petroleum waxes as well as lube oils.

The Lummus Oil Company, Ltd., and Foster Wheeler Corporation are the main contractors, but 200 British firms are supplying services and equipment.

An integral part of the plant will be a Thermofor catalytic cracking unit utilized to improve the quality and increase the quantity of gasoline produced.

Bulldozer in Action at Coryton.



Vacuum Oil Company's Coryton Refinery Process Scheme.

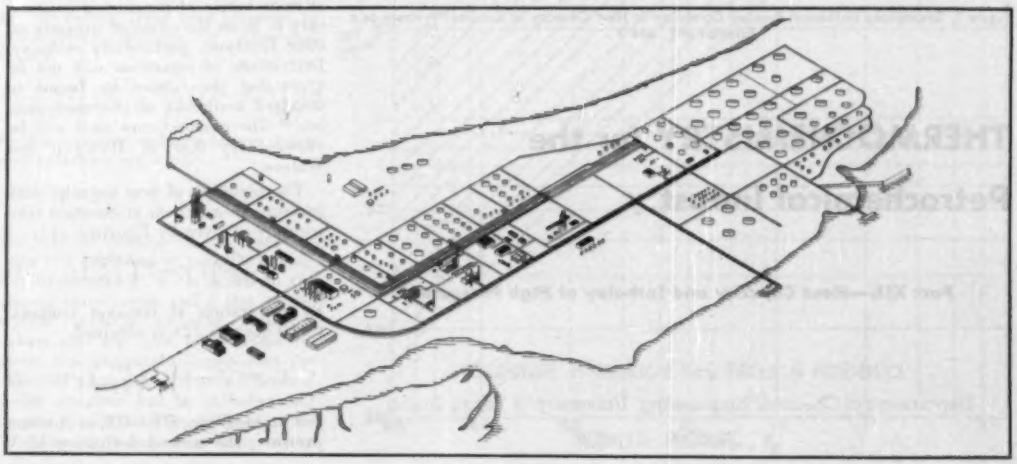
This unit will be the first cat cracker of its type to be built in England and the second in Europe. Its operation requires hot catalyst to be circulated within the unit at a rate of 300 tons per hour. The structure will be 250 feet high. Included in the scheme is a complete power station which will supply necessary steam and electrical power to the refinery. The boilers will be capable of raising 200 tons of steam per hour and the electricity generated would be enough to supply a town of 100,000 population.

The technique first used during wartime in the construction of the Mulberry Harbor will be used to install a new jetty for withdrawing cooling water from the Thames. A concrete caisson will be built in dry dock, floated into the correct position alongside the refinery, and sunk to form the jetty head on which will be mounted the pumps supplying 45 million gallons of river water per day to the refinery for cooling purposes.

The existing jetty and storage facilities will be modernized to enable super tankers carrying about 32,000 tons of crude oil to discharge at the rate of more than 2000 tons of oil per hour. The jetty will also be used for the outward shipment of products, including the transport of lubricating stock oils to the Vacuum works at Birkenhead. These oils will be transported in a coastal tanker which is being constructed for the Company by the Grangemouth Dock & Shipping Company, Ltd.

The plans also provide for the construction of a mechanical workshop, warehouse, office building, laboratory, loading racks, garage and canteen and housing for personnel.

Artist's Conception of the Completed Refinery at Coryton.



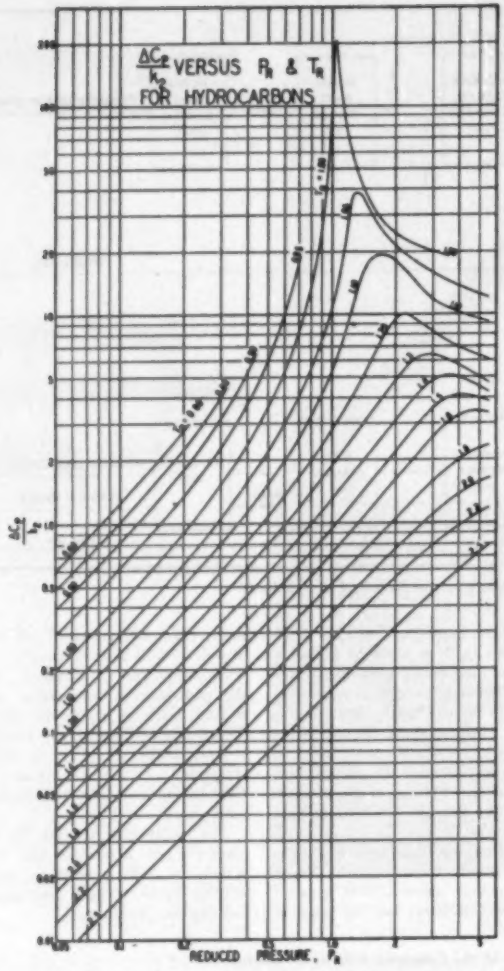


Figure 1. Generalized Isothermal Pressure Correction to Heat Capacity at Constant Pressure as a Function of P_r and T_r.

THERMOCHEMISTRY for the Petrochemical Industry

Part XIX—Heat Capacity and Enthalpy at High Pressures.

KENNETH A. KOBE and ROLAND H. HARRISON

Department of Chemical Engineering, University of Texas, Austin

THIS ARTICLE completes the series on thermochemistry for the petrochemical industry. Previous articles in this series presented the thermodynamic properties of a wide scope of compounds encountered in the petrochemical industry. All the data given were for gases at zero pressure, or for the ideal state. Since gases are never at zero pressure and frequently the reactions are conducted at relatively high pressures, it is necessary to know the effect of pressure on these functions. This article tells the engineer how to convert data for zero pressure to one atmosphere, ten atmospheres, 100 atmospheres, or higher if necessary.

Dr. Kobe is professor of chemical engineering at the University of Texas. Mr. Harrison is Carbide and Carbon Chemical Company fellow at the University.

Reprints of the entire series of 19 articles will be available early in the year at $1 per copy.

THE previous papers in this series have reported the heat capacities and enthalpies of many compounds using as a basis the ideal gas state of zero pressure or unit fugacity. In the symbols these thermodynamic functions should be represented as C_p° and H°, the degree sign indicating the standard state of the gas is one in which it is behaving as an ideal gas (which can occur only in the hypothetical state of zero pressure). Because reactions must occur at finite values of pressure it is necessary to know the effect of pressure on these functions, particularly enthalpy. Derivations of equations will not be given but these may be found in standard textbooks on thermodynamics.[1,2] The nomenclature used will be essentially that of Hougen and Watson.[3]

The variation of heat capacity with pressure in a system at constant temperature is given by Equation (1).

$$\left(\frac{\delta C_p}{\delta P}\right)_T = -T\left(\frac{\delta^2 V}{\delta T^2}\right)_P \qquad (1)$$

By integration at constant temperature Equation (2) is obtained.

$$C_p = C_p^\circ - T\int_1^P \left(\frac{\delta^2 V}{\delta T^2}\right)_P dP \qquad (2)$$

For an ideal gas, $PV = RT$, at constant pressure, the second derivative of V

TABLE 1

Heat Capacity and Enthalpy of n-Butane at Various Temperatures and Pressures

	0 Atm.		1.0 Atm.		C_p at 10 Atm.			C_p at 100 Atm.			H at 10 Atm.			H at 100 Atm.		
			C_p	H												
t°C.	C°_p	H°	Berthelot		van der Waals	Berthelot	C.P.P. Charts	van der Waals	Berthelot	C.P.P. Charts	van der Waals	Berthelot	C.P.P. Charts	van der Waals	Berthelot	C.P.P. Charts
100	28.19	2,513	28.39	2,478	29.07	30.17	34.4	.....	.....	.....	2,315	2,150	2,093	.....	.....	.....
500	47.30	17,984	47.32	17,977	47.43	47.52	47.6	49.10	49.55	50.6	17,923	17,914	17,810	16,903	17,281	16,594
1000	60.10	45,160	60.10	45,156	60.15	60.15	60.2	60.57	60.60	60.8	45,146	45,144	45,045	44,924	45,000	44,435

with respect to T is zero, showing that pressure has no effect on the heat capacity. The variation of enthalpy with pressure in a system at constant temperature is given by Equation (3).

$$\left(\frac{\delta H}{\delta P}\right)_T = V - T\left(\frac{\delta V}{\delta T}\right)_P \quad (3)$$

By integration at constant temperature Equation (4) is obtained.

$$H = H^\circ + \int_1^P \left[V - T\left(\frac{\delta V}{\delta T}\right)_P dP\right] \quad (4)$$

For an ideal gas the first derivative of V with respect to T is R/P, so that V — RT/P is zero, showing that pressure has no effect on enthalpy.

Use of Equations of State

The P-V-T behavior of an actual gas can be represented by an equation of state, such as the van der Waals Equation (5), Wohl Equation (6), or Beattie-Bridgeman Equation (7).

$$(P + a/V^2)(V - b) = RT \quad (5)$$

$$\left(P + \frac{a}{V(v-b)} - \frac{c}{V^2}\right)(V - b) = RT \quad (6)$$

$$P = \frac{RT}{V^2}\left(1 - \frac{c}{VT^3}\right)(V + B) - \frac{A}{V^2} \quad (7)$$

where $A = A_o(1 - a/V)$
$B = B_o(1 - a/V)$

The Berthelot Equation (8) is usually used to make the correction for pressure change when the pressure is low, as correcting from zero pressure to atmospheric pressure or somewhat higher.

$$PV = RT\left[1 + \frac{9}{128}\frac{P_r}{T_r}\left(1 - \frac{6}{T_r^2}\right)\right] \quad (8)$$

In this equation reduced temperatures and pressures are used.

$$P_r = \frac{P}{P_c} \qquad T_r = \frac{T}{T_c}$$

The critical pressures and temperatures can be found in suitable tables.[7] For hydrogen, 8° K. is added to the critical temperature and 8 atm. to the critical pressure to give corrected values that are used to calculate reduced temperatures and pressures for use with generalized charts. The Berthelot equation can be differentiated to give the first and second derivatives of volume with respect to temperature at constant pressure. These derivatives can be substituted in Equations (2) and (4) to give Equations (9) and (10).

$$C_p = C_p^\circ + \frac{324}{128}\frac{RT_c^3}{P_cT^3}(P) \quad (9)$$

$$H = H^\circ + \frac{9}{128}\frac{RT_c}{P_c}\left(1 - \frac{18}{T_r^2}\right)(P) \quad (10)$$

That the effect of pressure is small in changing from zero to one atmosphere is shown by calculating the heat capacity of *n*-butane at one atmosphere pressure and temperatures of 100°, 500°, and 1000° C. using the Berthelot equation. The values are given in Table 1. Although the change is small at a pressure of one atmosphere, it becomes much larger at 10 and 100 atmospheres. Table 1 shows the values of heat capacity and enthalpy calculated for these higher pressures using

Figure 2. Generalized Isothermal Pressure Correction to Enthalpy as a Function of P_r and T_r.

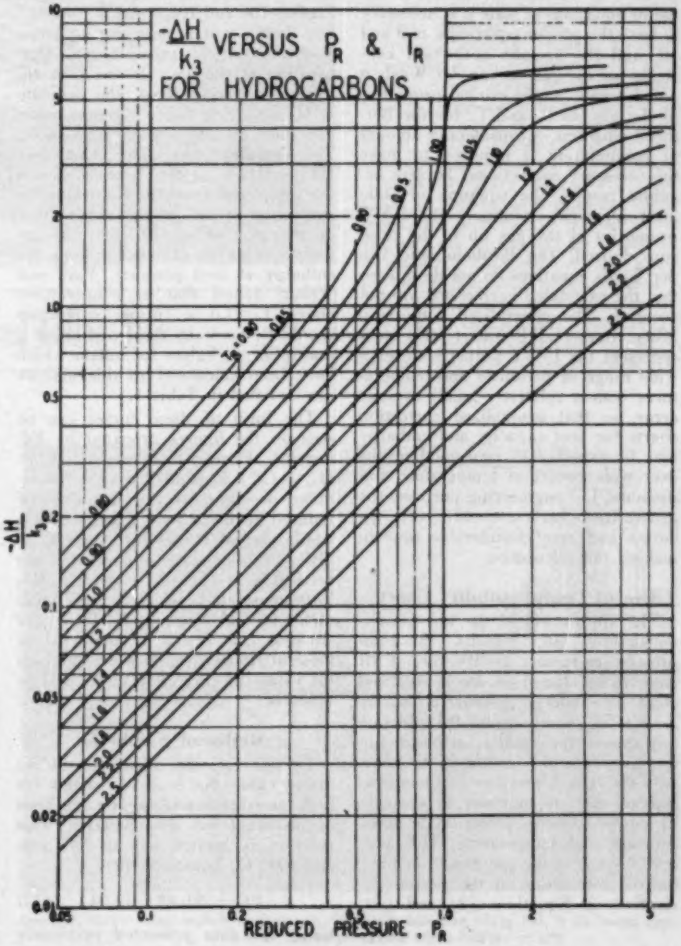


TABLE 2

Heat of Reaction for $CO + 2H_2 \rightarrow CH_3OH$ at 200 atm. and 400° C.

	CO	H_2	CH_3OH
Enthalpy at 400° C., H°	2848	2793	5580
Enthalpy at 25° C., H°	174.1	171.6	263.0
$H°_{400} - H°_{25}$, cal./g-mole	2674	2621	5317
Critical pressure, atm.	34.5	12.8 (+8.0)	78.5
Reduced pressure, 400 atm.	5.80	9.63	2.55
Critical temperature, °K.	133.16	33.26 (+8.0)	513.6
Reduced temperature, 400° C.	5.06	16.31	1.31
$(H° - H)/T_c$, C.P.P. Chart 106-6	—0.1	—4.	4.0
ϕ—Factor	1.0	1.0	1.02
$H° - H_c$ at 200 atm. and 400°	—13	—133	2090
H at 200 atm. and 400°	2861	2926	3490
$H^{200}_{400} - H°_{25}$, cal./g-mole	2687	2754	3227

$\Delta H = \Delta H°_{25} + \Sigma H_{(Products)} - \Sigma H_{(Reactants)}$

$\Delta H°_{400} = -21{,}684 + 5317 - 2674 - (2)(2621)$
$= -21{,}684 - 2599 = -24{,}283$ cal./g-mole

$\Delta H^{200}_{400} = -21{,}684 + 3227 - 2687 - (2)(2754)$
$= -21{,}684 - 4968 = -26{,}652$ cal./g-mole

both the Berthelot and van der Waals equations of state. Because the Berthelot equation was developed for correction at low pressures, it would not be used at 10 and 100 atm. For the use of equations of state it is necessary to have the proper equations, as 9 and 10, and the specific correction constants for the gas, as van der Waals a and b terms, or the critical properties of the gas, as P_c and T_c for the Berthelot equation. A considerable amount of computation is required to make the necessary corrections. To give accurate results, the equation of state must represent accurately the P-V-T properties of the gas up to the pressure desired. The Berthelot and van der Waals equations do not do this, so that the calculated corrections are not accurate. The generalized compressibility chart (C.P.P. Chart 103) does represent the P-V-T properties over a wide range of pressures and temperatures with a relatively small average error, so that generalized correction charts for heat capacity and enthalpy may be expected to give good results over wide ranges of temperature and pressure. For engineering purposes the generalized charts are sufficiently accurate and save considerable time in making the calculation.

Use of Compressibility Chart

The application of the law of corresponding states permits the compressibility factors, $z = PV/RT$, of all gases to be plotted on one generalized chart. The reduced pressure is usually used as the abscissa and the z-factors are shown for various reduced isotherms. Thus it is necessary to know only the critical pressure and temperature of the gas in order to evaluate its compressibility factor at a given pressure and temperature. This permits the use of the gas Equation (11) for the calculation of the partial derivatives in Equations (2) and (4).

$$PV = zRT \qquad (11)$$

Hougen and Watson[3] have carried out the graphical differentiation of the z-chart, followed by a graphical integration as indicated by Equations (2) and (4). These charts have been made Figures 106 and 108 in C.P.P. Charts.[4] For their use it is necessary to know only the critical pressure and temperature of the gas. On the heat capacity correction chart, the ordinate is $C_p - C_p°$, or the correction value that must be added to the $C_p°$ value. The enthalpy correction chart uses $(H° - H)/T_c$ as the ordinate. Hence the value read from the chart must be multiplied by the critical temperature of the gas before the corrected enthalpy value is calculated from the enthalpy at zero pressure. York and Weber[5] found that at temperatures above $T_r = 1.0$ a further correction should be made by the insertion of a multiplier, ϕ. Values for butane which have been calculated in this manner are included in Table 1.

The form of these curves can be seen on the figures prepared by Edmister.[2] Figure 1 shows $\Delta C_p/k_2 = (C_p - C_p°)/k_2$ plotted against the reduced pressure for various values of reduced temperatures. Figure 2 is a similar set of curves for $-\Delta H/k_2 = (H° - H)/k_2$. Edmister divides the correction, as $(C_p - C_p°)$ or $(H° - H)$, by a constant, k, which is a function of the critical temperature. The shape of these curves will be the same as those of Hougen and Watson, although the values of correction terms will be different.

Methanol Synthesis

To illustrate the calculation of enthalpy values and heats of reaction for high pressure reactions, the synthesis of methanol has been selected. This reaction is carried out at 200 atm. and 400° C., Equation (12).

$$CO + 2H_2 \rightleftarrows CH_3OH \qquad (12)$$

Using the data presented previously in Parts VII[5] and XIII,[6] the heat of reaction at the standard thermochemical temperature of 25° C. can be calculated from the heats of formation or combustion.

$\Delta H° = -48{,}000 - (-26{,}416) - (2)(0)$
$= -21{,}684$ cal./g-mole

$\Delta H° = -[-182{,}586] + [-67{,}636] + (2)(-68{,}317)] = -21{,}684$ cal./g-mole

For the heat of reaction at 200 atm. and 400° C. the enthalpies of the reactants and product must be calculated under those new conditions. This has been done using C.P.P. Chart 106. The necessary steps are given in Table 2. If the gases were in the ideal gas state, the heat of reaction at 400° C. would change by —2599 cal./g-mole methanol formed. However, the pressure markedly affects the enthalpy of the methanol vapor, changing it by 2090 cal./g-mole, whereas the enthalpies of the carbon monoxide and hydrogen change but little (—13 and —133 cal.). Because of this change in enthalpies of the reactants and products due to pressure, the heat of reaction at 400° C. and 200 atm. differs by —4968 cal./g-mole methanol formed.

Summary

The effect of pressure on the valves of thermodynamic functions cannot be neglected for high pressure reactions. For engineering purposes these corrections can be made most rapidly and accurately by using generalized charts based on the law of corresponding states and the equation $PV = zRT$.

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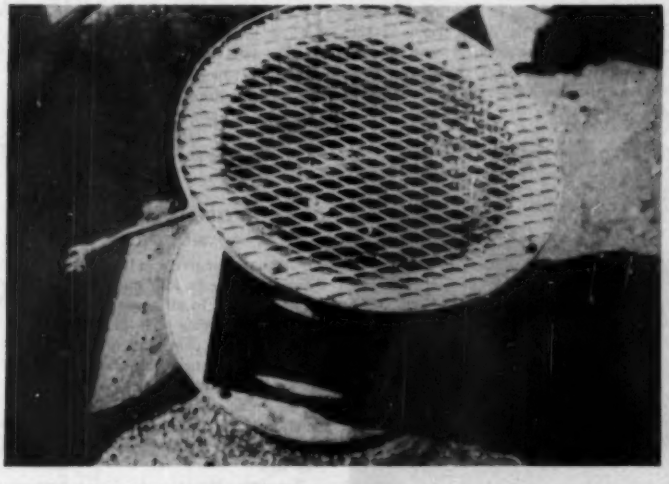
MAINTENANCE And OPERATION How To Do It—

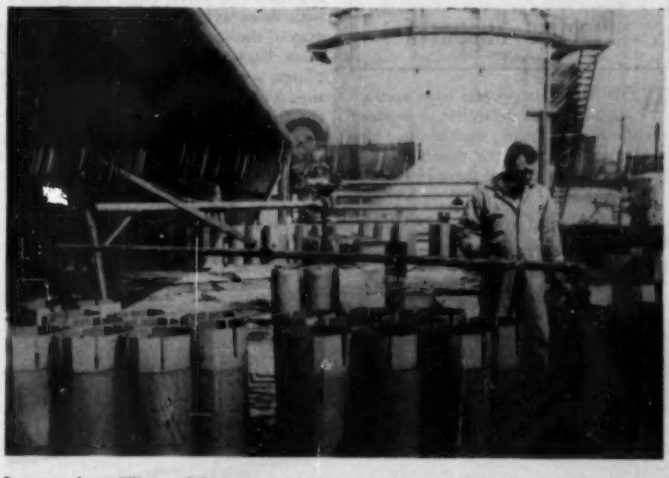


Portable Manhole Blower

INSURING safe working conditions in a column shut down for repair may be accomplished by the use of a portable manhole blower. The unit illustrated is made by installing a motor-driven fan in an oil drum. Both ends of the drum were fitted with wide flanges to set against the opening in the tower. Angle iron distance pieces placed on the outside of the fan case stiffen both flanges so the unit will withstand rough usage. The face of each flange is covered with expanded metal grating for protection of the fan blades against large objects and for protection of employes. Two employes can easily set the blower into the manhole and connect the wiring to a power outlet. Installed in one position, fresh air can be blown into the vessel; and by reversing the unit, foul air can be exhausted.

Counterbalanced Filling Line

SPEEDING up production in a packaging plant is a never-ending problem to refiners who market packaged products. In one asphalt plant production lagged because operators were overworked by a cumbersome filling line. The filling line was a joint of two-inch standard pipe unsupported except at the supply pipe junction. The bulk of the weight was carried on a special two-wheeled carriage so the filling operation might be done in a circle. In order to reduce the labor required in such a scheme, the original filling line was replaced by lighter piping and attached to the supply line with a packed swing joint. The carriage frame was raised 30 inches and fitted with a ring into which the hook of a turnbuckle was inserted. The opposite end of the turnbuckle was attached to a coil spring, which in turn was connected to the filling line with a D clamp. The D clamp provides adjustment for tension. With this new arrangement, the operator is relieved from lifting the weight of the filling line, since the spring counterbalances the weight.

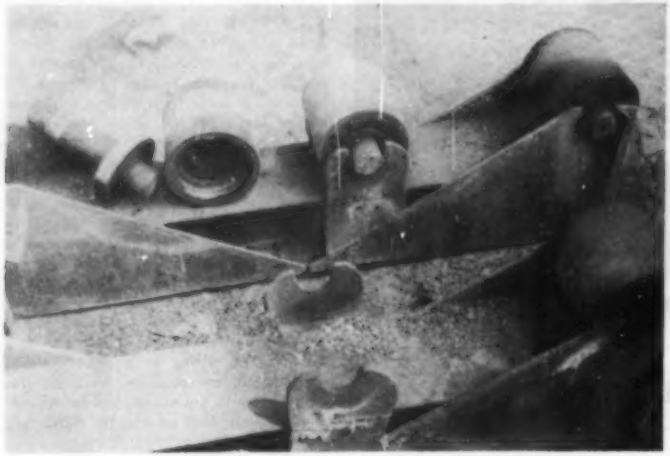


Operator, shown filling asphalt cartons with the counterbalanced filling line, is no longer overworked by the weight of the filling line.

MAINTENANCE And OPERATION
How To Do It-

Dolly for Welding Vessels

CONSTRUCTING and reconditioning cylindrical vessels can be expedited with a ball-bearing dolly of the type illustrated. Consisting of three identical parts, the dolly provides adequate vessel support for seam alignment. Each part consists of three ball-bearing rollers to accommodate two column sizes. The base was fabricated from I-beam stock to which side plates were attached to carry the rollers. The rollers are short nipples of heavy pipe, machined at each end to receive ball-bearing units. The ball-bearing units are inserted with a tight push fit. Short stub shafts are machined for a tight fit in the cone of the bearings and rest in notched plates welded to each side of the I-beam base. Bearings for this unit were slightly worn truck bearings obtained from the automotive shop. Vessels 6½ feet in diameter and 54 feet in length have been constructed on this dolly, each vessel weighing approximately 28 tons. Using well lubricated bearings, the welder was able to turn the vessel by hand without any difficulty.



Pipeline Supports

WHEN certain process lines are laid and it is not desirable to support them on overhead stanchions, provision can be made for expansion and contraction by placing these lines upon low concrete piers. Each line is fitted with shoes welded on the under side to match the position of the concrete piers. Each pier is faced with flat steel plates, securely anchored with foundation bolts, to supply a smooth surface for the shoes to slide across with the movement of the pipe. The shoes are made of sections of structural steel with the web welded to the line in such manner that the flanges are parallel to the face of the pier topping plates. The entire length of line supported in this manner is free to move as contraction and expansion changes the length between two points.

Nomographs for Designers and Operators

RAPID calculations through the use of monographs are useful to designers and operators where no more than slide rule accuracy is required. In this month's presentation of How To Do It starts a series of nomographs prepared by T. G. Hicks, Hicksville, N. Y., on problems recurrent in plant operation and design.

COST OF OPERATING ELECTRIC MOTORS

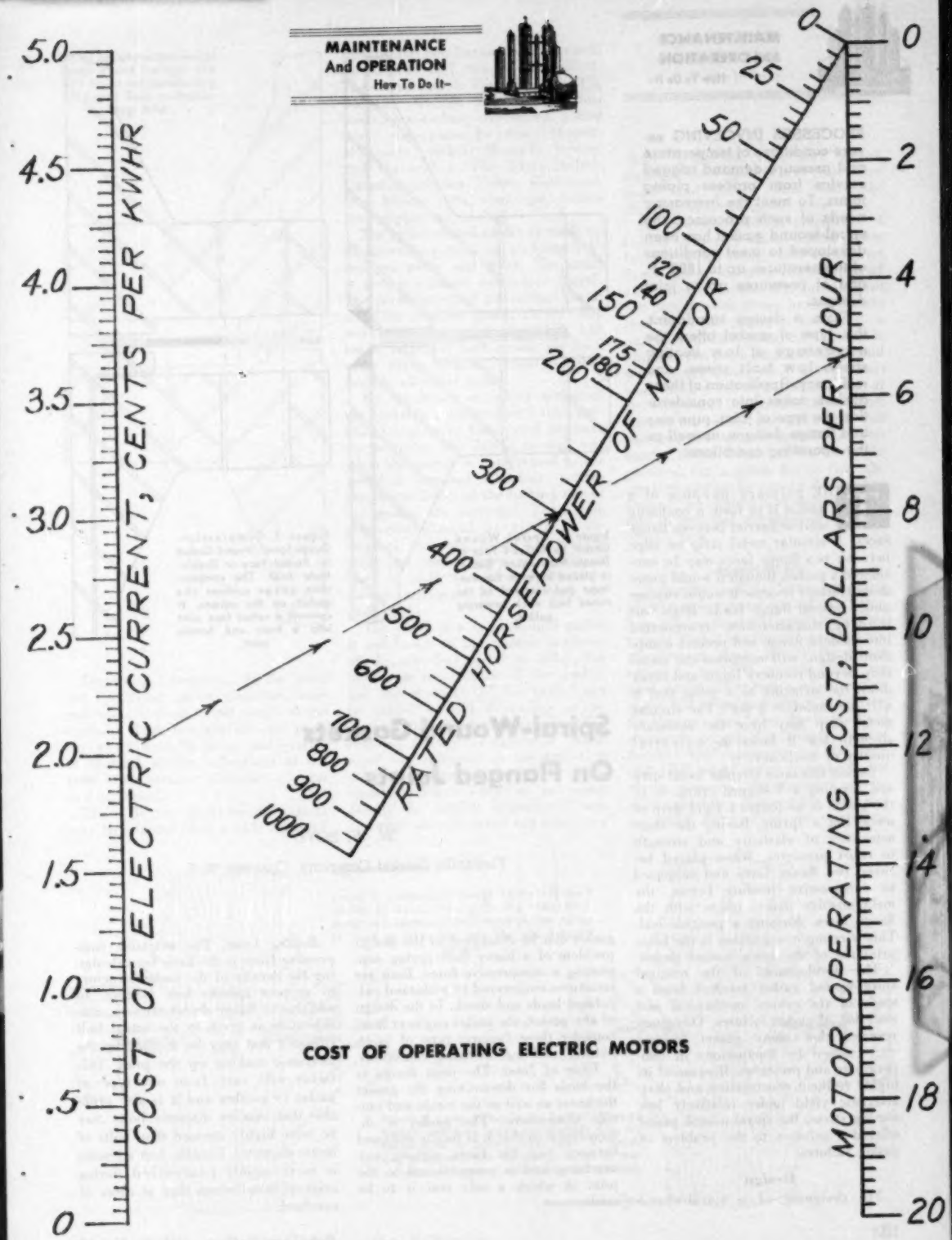
Alternating-current electric motors drive many units like pumps, compressors, and fans in all types of petroleum plants. Occupying the place they do, their operating cost is of major concern to all petroleum plant designers and operators. The chart on page opposite permits quick estimates of operating cost when cost of electric energy and rated horsepower of motor are known. Use it like this.

Example: What is the hourly operating cost of a fully loaded 300-hp alternating-current motor driving a refinery pump if electrical energy costs 2 cents per kwhr?

Solution: Enter the chart at the left and from a current cost of 2 cents per kwhr draw a straight line through 300 hp on the central sloping scale. Continue this straight line until it intersects the right hand scale and read $5.28, hourly operating cost.

By solving from right to left either the current cost, cents per kwhr, or motor horsepower may be found when the other two factors are known. Note that this chart is based on a motor efficiency of 85 percent, continuous full-load operation, and a power factor of 100 percent. Where the power factor is considerably less than 100 percent the results obtained from the chart are not as accurate as for the stated conditions. In all cases where exact operating cost must be found, computations will give more accurate results than the chart because chart scale dimensions cannot be made small enough on this size chart. For instance, in the above problem the exact cost is $5.26 per hour. The chart value of $5.28 is quite close and sufficiently accurate for the majority of calculations.

MAINTENANCE
And OPERATION
How To Do It-



COST OF OPERATING ELECTRIC MOTORS

PROCESSES INVOLVING severe conditions of temperature and pressure demand rugged service from process piping joints. To meet the increasing needs of such processes, the spiral-wound gasket has been developed to meet conditions of temperatures up to 1800° F. and of pressures up to joint designs.

From a design standpoint, this type of gasket offers the advantage of low seating stress, low bolt stress, and resiliency. Application of these gaskets takes into consideration the type of joint, pipe size and flange designs, as well as the operating conditions.

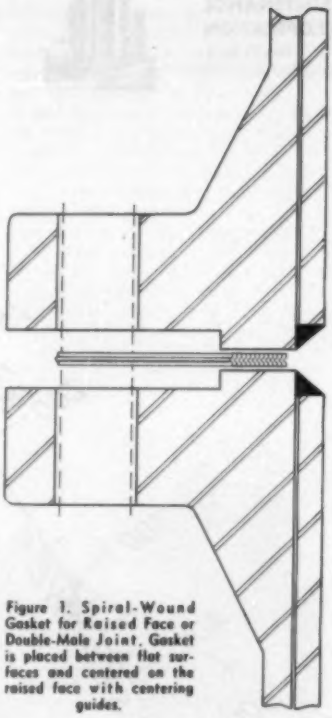


Figure 1. Spiral-Wound Gasket for Raised Face or Double-Male Joint. Gasket is placed between flat surfaces and centered on the raised face with centering guides.

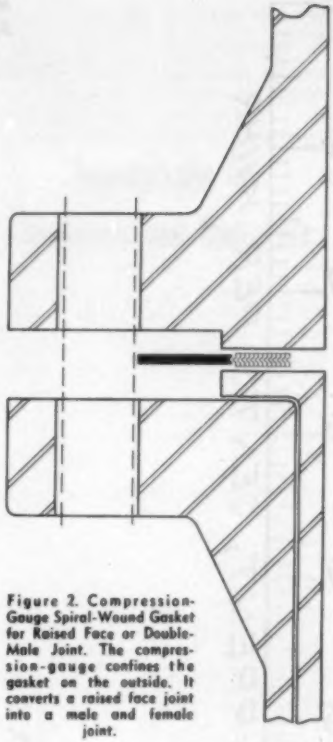


Figure 2. Compression-Gauge Spiral-Wound Gasket for Raised Face or Double-Male Joint. The compression-gauge confines the gasket on the outside. It converts a raised face joint into a male and female joint.

Spiral-Wound Gaskets On Flanged Joints

W. W. BOYD

Flexitallic Gasket Company, Camden, N. J.

THE primary purpose of a gasket is to form a confining wall or barrier between flange faces. A circular metal strip on edge between two flange faces may be considered a gasket, though it would prove unsatisfactory because it would rupture under normal flange loads. High bolt loading characteristics, incorporated into modern flange and process equipment design, will compress the metal strip beyond recovery limits and break down the structure to a point that it will not maintain a seal. The circular metal strip may have the necessary strength but it lacks the essential quality of resiliency.

Taking this same circular metal strip and forming a V-shaped crimp in it, the gasket is no longer a rigid strip of metal but a spring, having the characteristics of elasticity and strength to resist pressures. When placed between two flange faces and subjected to compressive loading forces, the metal-on-edge makes union with the flange faces, forming a positive seal. This V-crimp construction is the basic principle of the spiral-wound gasket.

The development of the original spiral-wound gasket resulted from a study of the causes, mechanical and material, of gasket failures. This study revealed that many gasket failures were caused by fluctuations in temperatures and pressures. Because of its highly resilient construction and characteristic yield under relatively low seating stress, the spiral-wound gasket offered a solution to the problem of gasket failures.

Design

The designing of a spiral-wound gasket can be compared to the design problem of a heavy duty spring supporting a compressive force. Both are structures engineered to withstand calculated loads and shock. In the design of any gasket, the gasket engineer must consider three factors: type of joint, bolting load and operating conditions.

Type of Joint. The joint design is the basis for determining the gasket thickness as well as the inside and outside dimensions. The gasket is dimensioned so that it is totally confined between two flat faces without any overhang and is proportioned to the joint in which a safe seal is to be made.

Bolting Load. The available compressive force is the basis for calculating the density of the gasket structure to support specific bolt loading. In addition to flange design stresses, consideration is given to the actual bolt stressing that may be applied by the mechanic making up the joint. This factor will vary from one type of gasket to another and it is also probable that smaller diameter bolts may be more highly stressed than bolts of larger diameter. Usually, bolt stressing is more rigidly controlled during original installations than at times of overhaul.

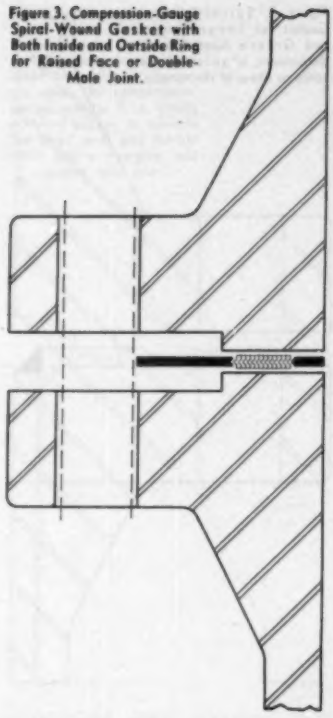


Figure 3. Compression-Gauge Spiral-Wound Gasket with Both Inside and Outside Ring for Raised Face or Double-Male Joint.

Operating Conditions. As the basis for specifying gasket materials, consideration is given to the nature of the confined fluid, temperature and pressure of the fluid, frequency and severity of thermal shocks, vibrations at the joint, line strains, abrasion, erosion and corrosion.

Materials for spiral-wound gaskets may be selected from a wide range of ferrous and non-ferrous *metals* as well as metallic and non-metallic *fillers*. The metals include Types 304, 309SCb, 347SCb, 316SMo and 430 stainless steels; low-carbon, cold-rolled, plated steel; phosphor bronze; copper; aluminum; nickel; Monel; Inconel and Hastelloy. The fillers include Canadian asbestos, Teflon, fibre sheet, blue African yarn, aluminum, Armco iron, copper and nickel.

The spiral-wound gasket is made up of alternating plies of preformed V-crimped metal and filler. The metal is always a single continuous length. The combination of pre-formed metal and filler gives the gasket its controlled resiliency. For unusually high bolt loads, relatively soft metals are used as a filler material, resulting in a flexible all-metal gasket.

The resilience or spring action of the gasket is correlated with the available compressive force used to make up the joint. The design is such that when the gasket is compressed to the specified terminal thickness, neither the elastic limits of the bolting nor of the gasket are exceeded. Thus, consideration should be given to the original make-up load, the relaxed load and the maintenance make-up load, in order to be certain that the proper resilience is built into the gasket.

The yield of a spiral-wound gasket is not based on the relative hardness of the specified metal or filler, but rather on the density of the gasket, and the density of the gasket can be varied without increasing or decreasing the effective gasket area. The required density, or degree of "hardness" or "softness" of the gasket, is achieved by varying the caliper of the specified filler. Variation in gasket density is usually apparent. There are more plies of metal and filler in a "hard" gasket than in a "soft" gasket, although both gaskets may have fixed inside and outside dimensions and the same effective gasket area.

As an example of the magnitude of bolting stresses, a spiral-wound gasket for any series 6-inch IPS raised-face flange has an effective contact area of 14.7 square inches. For a standard 150-pound series flange having carbon steel bolts the gasket is subject to a unit load of 3285 psi at 20,000 pounds initial stress. For a standard 600-pound series flange having alloy bolts the unit load is increased to 13,500 psi at 30,000 pounds initial stress. These bolt stresses are considered as nominal and can be varied to meet specific requirements. Regardless of bolt stresses specified for a given flange size, the spiral-wound gasket can be designed to support the applied load without variation in terminal thickness or effective contact area.

Application

Refineries and natural gasoline plants employ spiral-wound gaskets on both process lines and steam lines. This type of gasket has found its widest application in steam service for flange series up to 1500 pounds. They are used extensively in hydrocarbon service in the 150-pound and 300-pound series, the limited range being due to the rigid standards set up for ring-type joint flanges. Applications in the 600, 900, and 1500-pound series have been due to the desire of the operator to employ raised-face flanges for easy disassembly. Because of its resiliency,

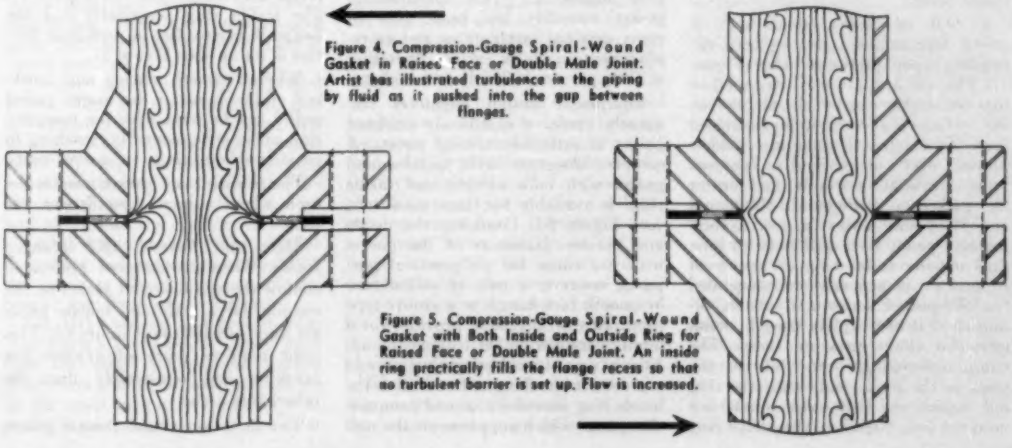


Figure 4. Compression-Gauge Spiral-Wound Gasket in Raised Face or Double Male Joint. Artist has illustrated turbulence in the piping by fluid as it pushed into the gap between flanges.

Figure 5. Compression-Gauge Spiral-Wound Gasket with Both Inside and Outside Ring for Raised Face or Double Male Joint. An inside ring practically fills the flange recess so that no turbulent barrier is set up. Flow is increased.

maintenance personnel have used this type of gasket between flange faces which have become pitted, warped or slightly deformed, and when flange faces cannot be brought up to exact parallel planes.

On ASA and API fittings, the pipe size and the flange series determine the right spiral-wound gasket to use, not the size of the gasket in inches alone. A spiral-wound gasket measured with a rule frequently can be the wrong gasket, both as to size and as to series. It is also wrong to conclude that a spiral-wound gasket built for a higher series will perform satisfactorily in a lower series flange. For example, the seating stress for a 900-pound series gasket might be beyond the seating stress that could be developed with a 300-pound series bolting. In gasket applications particular attention should be directed to the type of joint.

Raised Face ASA Flanged Joints. The simplest flange assembly and the easiest to make or break is the raised face or double male joint. (See Figures 1, 2 and 3). Space required for disassembly, alignment and assembly is at a minimum.

Spiral-wound gaskets for the raised face or double male joint are approximately dimensioned as follows:

1) I.d. of gasket equals o.d. of pipe plus $\frac{1}{4}$ inch with the exception of certain small sizes having a limited gasket seating surface (see Figure 1). The i.d. is calculated to allow inside clearance for screwed-on, round-cornered Van Stone and slip-on flange joints, serving also for weld-neck and lapped flange joints.

2) O.d. of gasket equals o.d. of raised face minus $\frac{1}{8}$ or $\frac{1}{4}$ inch depending upon pipe size. (See Figure 1.) The o.d. and i.d. are calculated so that the gasket can be placed between flat surfaces and centered on the raised face. Two integral centering guides, placed over diametrically opposed bolts, facilitate assembly and center the gasket on 150-pound, 300-pound and 400-pound series flanges. A compression-gauge style gasket (with integral outside metal ring as shown in Figure 2) is generally recommended for 600-pound series and above, although it is also widely used in refineries for lower pressure series. The compression-gauge ring i.d. is the same as the gasket o.d. while the ring o.d. equals the bolt circle minus one nominal bolt diameter. The gauge ring provides a practical measure of bolt stress as related to gasket yield, and centers the gasket, facilitating assembly of the joint. (See Figure 2.)

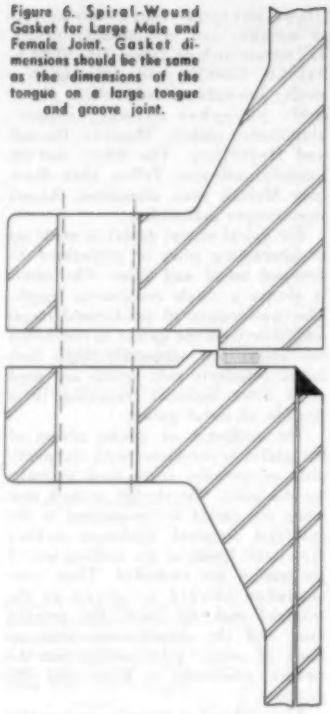


Figure 6. Spiral-Wound Gasket for Large Male and Female Joint. Gasket dimensions should be the same as the dimensions of the tongue on a large tongue and groove joint.

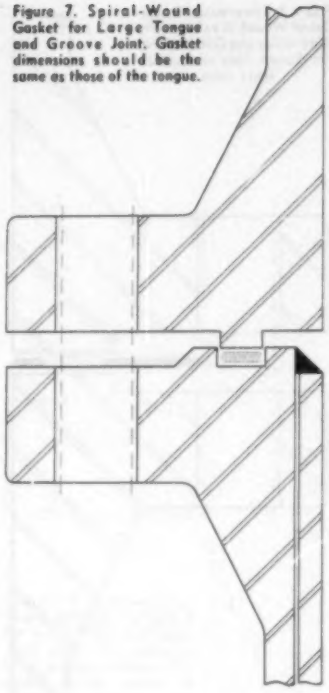


Figure 7. Spiral-Wound Gasket for Large Tongue and Groove Joint. Gasket dimensions should be the same as those of the tongue.

The compression-gauge style gasket with outside ring in effect converts a raised face joint into a male and female joint which has the advantage of confining the outside of the gasket but lacks the disadvantages of disassembling the male and female joint. (See Figure 2.) This spiral-wound gasket assembly has been used in many original installations and as replacement in steam service operating at 1500 psi per 1000° F. and higher.

Equipment design engineers frequently prefer a completely confined gasket at extremely critical points. A compression-gauge style spiral-wound gasket with both outside and inside rings is available for these conditions (see Figure 3). Confining the inside and outside diameters of the gasket with two rings, for all practical purposes, converts a pair of raised face or smooth face flanges to a groove-type joint. This arrangement provides for a totally confined gasket without the additional cost of machining a tongue and a groove in the flanges. In addition the inside ring provides a second compression-gauge which supplements the outside ring, preventing radial movement of the gasket under extremely high bolt loading. Use of the inside ring minimize the possibility of gasket contamination of the confined fluid.

The inside ring has another important advantage. There is a certain amount of skin friction in every pipe, which sets up eddies in the passing fluid. At the joint, this friction is increased as the fluid pushes into the recess between flanges (see Figure 4). The inside ring practically fills the flange recess so that no turbulent barrier is set up (see Figure 5).

Where frequent making and breaking of the joints is necessary, gasket *refills* can be used with the compression-gauge style assembly, resulting in considerable savings in gasket costs.

The inside ring gasket cannot be used where slip-on type flanges are used.

Male and Female ASA Flanged Joints. When the designer prefers to confine the spiral-wound gasket on the outside, large male and female joints are very satisfactory (Figure 6). This joint requires more clearance for breaking and re-assembly than the raised face joint.

For large male and female joints,

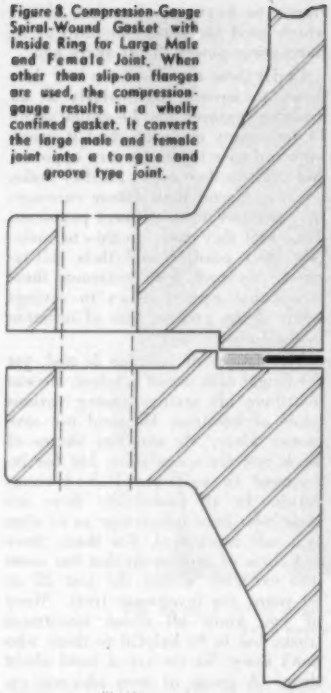


Figure 8. Compression-Gauge Spiral-Wound Gasket with Inside Ring for Large Male and Female Joint. When other than slip-on flanges are used, the compression-gauge results in a wholly confined gasket. It converts the large male and female joint into a tongue and groove type joint.

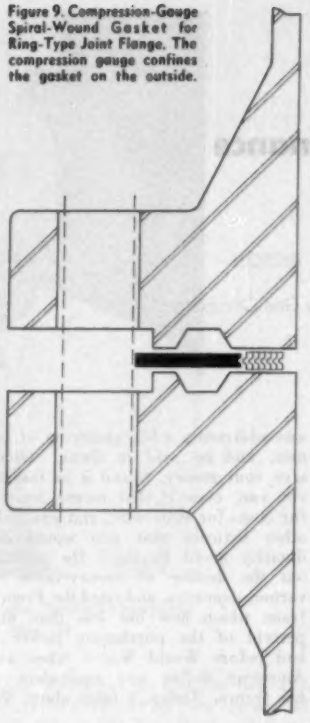


Figure 9. Compression-Gauge Spiral-Wound Gasket for Ring-Type Joint Flange. The compression gauge confines the gasket on the outside.

spiral-wound gasket dimensions are the same as those used on the large tongue and groove joint. These gasket dimensions are the same as those of the tongue on the large tongue and groove joint (see Figure 7). When other than slip-on flanges are used, an inside compression-gauge ring gasket will in effect transform the large male and female joint into a tongue and groove joint by confining the gasket both inside and outside (see Figure 8).

Spiral-wound gaskets are used infrequently on small male and female joints and then mostly on special equipment. They are recommended only where very heavy pipe wall thicknesses are used.

Tongue and Groove ASA Flanged Joints. There are many installations of spiral-wound gaskets in tongue and groove joints in the 1500-pound, 1000° F. range on steam. This joint is an excellent choice when the designer wishes to confine the gasket on both the inside and outside.

Spiral-wound gasket dimensions for the tongue and groove joint should be the same as the dimensions of the tongue, not those of the groove.

The large tongue and groove joint (see Figure 7) is more widely used than the small tongue and groove joint. Care should be taken in making up the small tongue and groove joint to avoid over-compression of the relatively small area of the gasket as compared to the available bolt load. In addition, the relatively narrow tongue on a heavy fitting is subject to damage and requires careful handling until the joint is made up.

With any recessed face joint—tongue and groove or male and female—some clearance is required to make and break the joint and it also must be watched for right and left positions. Some difficulty is encountered at times in removing the gasket from the groove but this is not serious.

Ring-Type ASA Flanged Joints. Because of its design, the ring-type flanged joint occupies a special position in regard to spiral-wound gasket application. The petroleum industry has made some modifications in ring-type joint standards in recent years by specifying raised-face flanges and compression-gauge type gaskets for high-pressure steam lines. Though the ring-type joint is not *designed* for any gasket other than the normal oval or octagonal rings, the compression-gauge type spiral-wound gasket is now used for hydrocarbon service on ring-type joint flanges already installed because of easy making and breaking of joints.

Where the flanges are not of the slip-on type, spiral-wound gaskets of the compression-gauge style are available for most ring-type joints. The fitting ranges are 2½ inches IPS and higher in the 150 to 600-pound series and from ½ inch IPS and higher in 900 and 1500-pound series. The gasket seating surface is the area between the pipe orifice and i.d. of the ring groove (see Figure 9).

Where the compression gauge style spiral-wound gasket is used, a "breakaway" distance of only about 1/16 inch is needed to break or make up the joint, as compared with ¾ to 1-inch breakaway distance when oval ring is used. The compression-gauge style spiral-wound gasket in effect converts a ring-type joint into a male-and-female type joint, since the compression-gauge confines the gasket on the outside.

A few special applications of the compression-gauge style spiral-wound gasket have been made where it was necessary to mate a raised-face flange to a ring-type joint flange of the same IPS and series. The compression-gauge style spiral-wound gasket when made to fit the ring-type joint serves as a transition gasket in such cases.

There has been a definite trend away from ring-type flanged joints for several reasons. First, ring-type joints are generally of higher initial cost. Second, they are difficult to break down and reassamble in certain locations. Third, they occasionally fail to make a satisfactory seal when the confined fluid is a non-coking gas, such as steam, where subject to sudden changes in temperature. Fourth, during overhaul of some services, ring-type joints require relapping and purchase of oversize rings which contribute to higher maintenance costs.

Non-Standard or Special Joints. To design the right spiral-wound gasket for a special joint assembly, the gasket engineer requires complete data on the application. This includes the bolt loading or compressive force, the type of joint, the pressure, the temperature, the fluid to be handled, frequency and severity of thermal shocks, vibrations at the joint, line strains, abrasion, erosion and corrosion. These factors will determine the metal and filler material specifications as well as its physical construction or density.

Reducing Flanges. A spiral-wound gasket for reducing flanges should be made to fit the larger of the two pipe sizes involved at the joint. For example, on a raised face joint 8 inches to 6 inches inside pipe size, an 8-inch gasket should be used.

The Engineer's Special Interest in Finance

I. ARTHUR ANSON

Vice President, Bell Oil & Gas Company, Tulsa

HOW is the engineer concerned with finance? Rarely is he called into consultation on financial problems except to compare pay-outs on competing proposals for installations or operating hook-ups. In general, engineers are expected to be unacquainted with financial matters and to proceed on one simple rule: buy the best, no matter what it costs, as in the end, the best will cost the least.

However, the engineer has a special interest in finance. He can put money to work better than anyone else. The question is, how is the engineer to get hold of the money? The answer is—save it! Of course this sounds like nonsense. Most young engineers find it difficult to live within their income, and very difficult indeed to save. Moreover, if they do manage to save, the accumulation of many years' savings would not suffice for a down payment on any worth-while enterprise.

Nevertheless, he must save if he has financial ambitions. Furthermore, he must interest himself in the financial aspects of the operations in which he is engaged, even though he has few opportunities to study the economic phases of his enterprise. Here, therefore, is the task, to evoke hope out of a hopeless situation, to justify saving and studying, when there's nothing left to save, and nothing exposed for study.

Why Save?

Indeed a preliminary justification must be made. Why should anyone save these days, when the menace of inflation threatens to wipe out the value of savings? This is a question asked by all thinking people. One answer I heard not long ago, given by an economist, a vice president of a large bank, was direct and plain. He was addressing a big gathering of oil men, and he said to them, "Don't save your money. Spend it as fast as you can, even if that means buying fur coats for your wife, and grasping other luxuries that you would ordinarily avoid buying." He pointed out the decline of money-value in various countries, and cited the French franc which now has less than one percent of the purchasing power it had before World War I when one American dollar was equivalent to five francs. Today, it takes about 350 francs to buy one American dollar which itself has about one-third of its purchasing power of 40 years ago.

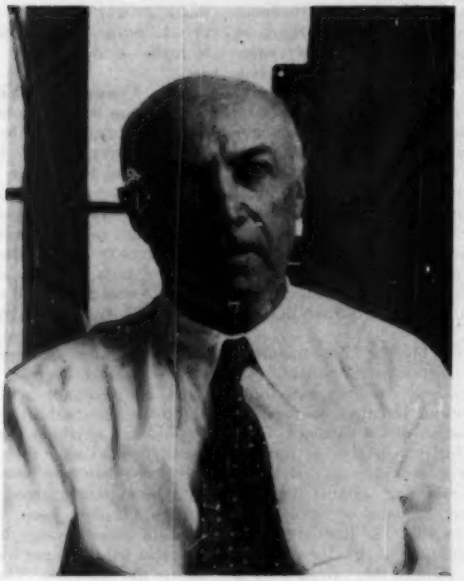
YOU MAY BE ASKING yourself—why this article? Yours is a legitimate question for this paper is directed principally to the relatively young man, just beginning his career, and the major portion of our readers are experienced, mature engineers. However, the presentation is so concrete in reasoning and suggestion, that we feel it will be of value to all engineers, no matter what their degree of experience. Although financial knowledge is seldom considered a segment of the engineering field, it is true that financial understanding of an organization's operations will be of direct benefit to the organization, and probably of indirect reward to the employe engineer. Conversely, the engineer who understands and profits from a private savings program, receives direct benefits himself, and indirectly benefits the company by attending to his work with an untroubled mind.

Under these circumstances how dare I say to anyone, particularly to an aspiring engineer, that he should save? In fact many engineers find it necessary and wise to do the very opposite. Not only do they spend all they make, but they spend their future earnings, by purchases on installment payments. They feel they must do this to maintain their position and their self-respect. My task is to overcome these formidable oppositions to saving: needs of the present, fear of inflation in the future.

The danger of inflation is real, yet the frugal man is not helpless. He can distribute his savings among various types of holdings. He need not save money alone. He can buy shares of stock, not for speculation, but for investment in well-established enterprises. In all probability there are some who have misgivings as to what is a safe investment. For them, there is a form of investment that has come into existence within the last 25 or 30 years, the investment trust. Many of you know all about investment trusts, but to be helpful to those who don't know, let me say a word about them. A group of men who are experts in the field of investments, organize an association which may be compared with a savings bank but with this difference. A savings bank usually invests its money in bonds, mortgage loans, etc. Generally speaking, the banks do not buy shares of stock and are prohibited by law to do so. A bank's distinctive quality is its liquidity. It must always be in position to redeem in cash on demand, whenever depositors desire to make withdrawals. If they turned their holdings into stocks, which represent shares in business enterprises, they would be at the mercy of the stock market, which hardly ever stands still, and does not always go up.

The Investment Trust

The investment trust puts its money into shares of stock, and takes the risk of advance or decline in the stock market. If you put your money into such a trust, at a cost of about 7½ percent above its liquidating value, you can get your money whenever you wish, but probably not the same amount that you put in. You will get either more or less than your outlay. You get your investment or deposit back in ratio to the value of the trust's holdings. Some of these trusts, called open-end or mutual funds, publish their liquidating values twice daily, morning and afternoon, and permit



The author, I. Arthur Anson of Tulsa. Detailed biographical sketch appears on page 158.

withdrawals to be made at any time, at the published value. I am not advising anyone to put *all* his savings into investment trusts. I certainly don't do it, but I do have a couple hundred shares in a closed-end trust which has so good a record for sagacious investment of its resources, that it is generally valued at about $5 per share more than its liquidating value. A closed-end trust is one which is probably listed on the stock-exchange, with a fixed capital, which is not increased day by day by new sales of newly issued capital shares, such as are constantly on sale by open-end trusts.

A thrifty man can put some money into U. S. government bonds, some into a savings bank, some into an investment trust, some into real estate, as to buy his home on installment payments. By such diversification he can protect his savings to a large degree against the hazards of inflation.

Need for Saving

Perhaps you are satisfied that by using these suggestions, you can readily overcome the dangers of inflation, but to ovecome the demands of the present is not so easy. Certainly it is difficult to say to anyone, "do without," yet that's exactly what one must command oneself, if one sets ambition above present satisfaction. I am not advising ambition! You are financially ambitious or you are not, and I have no comment on your choice and your policy. But if you are ambitious, or want to be, this is one way your ambition may be realized, if it is your ambition to advance financially. The way is to save money, knowing full well that you cannot save enough to pay for a start in business, particularly in the kind of buiness which will put your engineering knowledge and ability to use. If you go along with me thus far, then we are in position to declare why it is necessary to save, namely for two reasons. First to train yourself in handling money, and thus to know something about finance.

The second reason, the main point of this discussion, is this: The capable engineer, ambitious for financial success, will some day encounter a business man who will supply the needed finances, and between them, an enterprise will be founded that will prove profitable for both. There is something mystical about this statement. It is like saying that for every man or woman there is a sweetheart, who will come in right time, if you prepare yourself for the meeting. It amounts to saying that the world is full of moneyed people who would like to tie up with engineers to form a money-making team. This I believe to be true, as true today as it has been for many generations, perhaps truer than ever. There are many people who have acquired money by lucky strikes, or by inheritance, or by painful accumulation in a difficult or unpleasant business, who are on the lookout for capable engineers, with whom to make a partnership or profit-sharing deal whereby they can put their money to use for financial profit. But the engineer they seek must be a business man in some degree, a man of substance and reliability, in a word, a man who has saved some money.

One may ask why must one save money, to prove oneself a man to be relied upon? The various explanations may be compressed into the simple statement that a man that saves is a man that can say "No." A "No" that is merely negative is not much of a qualification for a business or a man. But there is something affirmative about the "No" that is expressed in savings. It means not only "Do Without," it also means "Make Do," or as the Navy puts it "Do the most with whatever you've got." The engineer who has the quality of "Make Do" is esteemed by a business man, who is likely to be somewhat dubious of engineers, especially those who have unlimited ways of spending his limited money. The man that has hold of a goodly sum, and is ambitious to increase it, is bound to be wary of an engineer that knows only how to spend, but does not know how to avoid spending.

Advancing One's Trading Position

Moreover, the more money the engineer possesses, the better deal he can make with his prospective financier. The deal may vary from a one percent interest in the joint enterprise, to perhaps 50 percent. When the engineer enters into the negotiation, not empty-handed, but with a sum of money that he is willing to risk in it, his trading power is advanced considerably. His standing is improved first because he has saved; secondly, because he is willing to risk his savings. This means a great deal to the financier who is debating whether he should risk his assets on a deal in which the engineer is to be the active manager and money-maker.

Some of you may think this is all fantasy, or at any rate it applies to times gone by, but has no real reference to the present. To my own knowledge, such deals have been made, and are being made continually and frequently these days. Perhaps "frequently" is not the right word. Maybe one such deal a year in Oklahoma would be considered frequent. I know of a firm in Texas, organized only a few years ago, whose engineer-partners made enough money in a few

years, to permit them to retire in fine shape, if they chose to do so. I know of another, organized this year, which I believe will make an equally good record. You can be certain that money is at hand, smart money, ambitious money, in the hands of people who, for reasons of their own, would be glad to let someone else exert the thought and labor and worry that usually attend an active business. Maybe you are the man they are looking for.

Who is that man? It is not the one that earns $1000 per month. He needs no counsel, at any rate not from me, on this subject. I am thinking of the man that draws, let us say $300 to $500 per month, minus deductions for taxes, etc., and has a wife and children to support. He is saving 10 percent to build a basis for future enterprise. He and his wife are invited to a reception to meet the company executives. His fellow-engineers and their wives will be there. But his wife says, "No dear, I cannot go, I have nothing fit to wear for the occasion. You had better go alone. My shabbiness would disgrace you." The engineer looks in his saving book, and wonders. You and I are wondering along with him.

Abraham Lincoln said, "I will study and get ready and maybe my chance will come." You may change this a bit to read, "I will study and *save* and get ready, and maybe my chance will come." But suppose no chance comes? Are you in any worse position for having studied and saved? It needs no argument to prove that your study of the business aspects of your work is worth-while, and is likely to bring you promotion in your present employment. But how about the saving of money? It may turn out that your savings and investments were ill-advised, ill-chosen, and quite disappointing.

Capitalism vs. Communism

Nevertheless, in the face of this risk, saving is to be recommended, despite the fact that your neighbors and competitors are forging ahead in the enjoyments of daily life, and gaining in social and professional standing by expending their funds in such manner as will produce immediate benefits. At this point the argument has a double bias, of a political nature. First there is the bias in favor of capitalism versus communism, for saving is at the basis of capitalism. Self-denial by free men is a means of serving the future of the individual and of human society, by free-will and unforced sacrifices of present good, to accumulate the foundations for future growth. If this is true, and I believe it is, then who more than engineers shall willingly take the risk of savings?

The second bias is of the moment, and may be described as patriotic. To save is one way, and an important way, to prevent inflation, to forestall the depreciation of the currency. Insofar as saving is effective in this regard, it is effective in our struggle, in hot or cold war, against the Russian menace. Students of Soviet literature tell us that the Russians don't intend to conquer us on the military battlefield, though they are active in military preparation. Their strategy is to extend the iron curtain and to shove behind it one country after another by fomenting civil war, as in Korea, Iran and Indo China. Meanwhile, they will exhaust our strength, spent in unavoidable military preparation for a war they plan to avoid, by winning without it. They can win, so they are convinced, by driving us into such inflation and cyclic upheavals of high and low prices, that we will collapse of our own instability.

Capitalism is dynamic, and thrives on change and movement. But the movement must have an inner stability, comparable to the whirling of the earth on its axis and thru its solar orbit. The sort of cataclysmic, wobbly movement that our economy experienced in the depression of the 30's, and that is to come again according to various forecasters besides the Russians, is fatal to civilized capitalism. The value of property is expressed in money, and if money is of such uncertain value, as to be of no worth, or worthless, then the future of private property or private enterprise is really in danger.

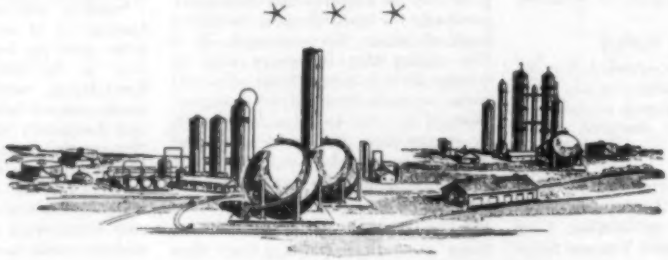
Frugality a Virtue

There are those who hold the opinion that frugality is not a virtue. In fact they propound the idea that saving is sinful because in their view it is detrimental to the national economy. They want everyone to spend as much and as fast as he earns so that money will circulate freely, production rates will be high, full employment will prevail, and the ghost of unemployment will vanish. It appears to be their view that we can all rely on such provisions as unemplomentinsurance, social security, and various types of insurance against accident, or disease, or disability. I doubt that I could say anything that would persuade them to alter their views. However, even they may be convinced that the type of saving urged is really productive. It does keep money in circulation since savings banks and investment trusts do not hide the money under the mattress. They put it to work and keep it in constant and working circulation.

About 100 years ago, a famous piece of advice was given, lingering as a tradition in our country. The advice? "Go west young man." Not everybody took the advice, nor did it fit everybody. Look at the West today and say, was it good advice for those who took it? A generation hence, look again and see what's happened to those that gave ear to these simple words, "Save, young man."

It is not only in the spirit of patriotic self-sacrifice that I counsel you to save, though I do repeat that saving, and abstaining from reckless buying, are necessary steps against inflation. It should be no surprise that individual benefit should be in accord with national welfare. My thought is that whoever saves, helps his country, and if that mystical union of financier and engineer shall come to pass for any of you, and I hope for all of you, there will be a realization of the engineer's special interest in finance.

* * *



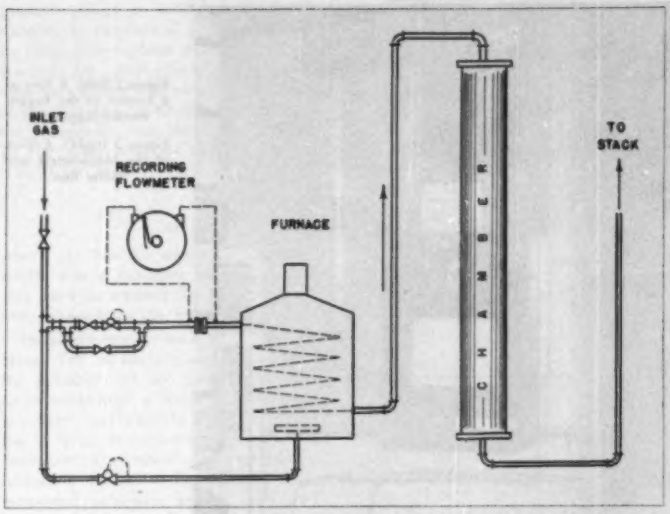


Figure 1. Flow Diagram of the Experimental Apparatus.

Heat Transfer and Pressure Drop In Fixed Beds of Spherical and And Cylindrical Solids

Part I. Pressure Drop and Packed Bed Characteristics.

JOHN M. CAMPBELL and R. L. HUNTINGTON
School of Chemical Engineering, University of Oklahoma, Norman

THE VARIABLES involved in any packed bed transfer have been developed in previous works but in some cases the data are conflicting and in others only a small range of particle or chamber sizes have been investigated. The work reported here was undertaken to extend and clarify the existing knowledge of fixed beds of packed solids.

This, the first of a series of two articles, presents original data and correlations for predicting the pressure drop and physical characteristics of common heat transfer packing materials. Particular emphasis has been placed on the effect of chamber diameter. Wherever possible, data normally available in process specifications have been used as variables in order to facilitate design calculations.

A review of the literature is included. Part II will follow in an early issue.

Mr. Campbell's present address is Black, Sivalls and Bryson, Inc., Oklahoma City.

ONE of the most important aspects of the flow of fluids through fixed packed beds is the pressure drop for it enters into the economics of a process. In fact, in the average design the lower range of pellet sizes is fixed by this consideration even though smaller sizes might give better heat and mass transfer. Extensive work over a period of years indicates the chief variables affecting pressure drop to be:

1) Packing dimensions.
2) Tube diameter.
3) Fractional Voids.
4) Shape of particle.
5) Particle surface roughness.
6) Bed configuration.
7) Mass velocity.
8) Viscosity.
9) Density.

With all of these variables to be considered it is understandable that a universal correlation is difficult. Instead, most work has been more or less sub-divided to include the packings in a given field such as broken solids, geometric solids and those special shapes such as Raschig rings and Berl saddles. Even though the individual correlations vary, they can all be based on the fundamental properties of a fluid in motion.

The Momentum Equation and Dimensional Analysis. The motion of any fluid is governed by the Navier-Stokes equation[14] which is composed of terms having the dimensions of force divided by volume. This equation represents the local and convective accelerations, internal friction, external forces (gravity) and pressure differences in the system. This type of equation, which can best be handled with vector notation, lends itself to solution by vector analysis which accounts for the wide use of dimensionless groups. Such groups may sometimes be obtained by the division of some terms of the Navier-Stokes equation by certain other terms. In this case both the Euler and Reynolds groups may be obtained, which may then be expressed in a functional equation of the type

$$\frac{P}{\rho V^2} = \int\left(\frac{D_t}{L}, \frac{VD_t}{v}\right) \qquad (1)$$

Past work has indeed developed such an equation

$$P = \tfrac{1}{2}\rho V^2 \times \frac{L}{D_t} \times \int(Re) \qquad (2)$$

For correlation purposes though it is convenient to develop this expression in terms of an empirical term known as a friction factor, which may be defined from

$$K = \tfrac{1}{2} f \rho V^2 A \qquad (3)$$

where f is a function of Reynolds Number (Re). Experimenters then have found it expedient in the case of packed beds to show plots of f, f/Re, and fRe^2 versus Re.

This number is usually expressed as $D_p G/\mu$ where D_p is defined as the equivalent particle diameter. The modified Reynolds number was first developed for spheres by Chilton and Colburn,[5] and has since been expanded to other shapes by many investigators who, by definition, used D_p as the diameter of a sphere having the same sur-

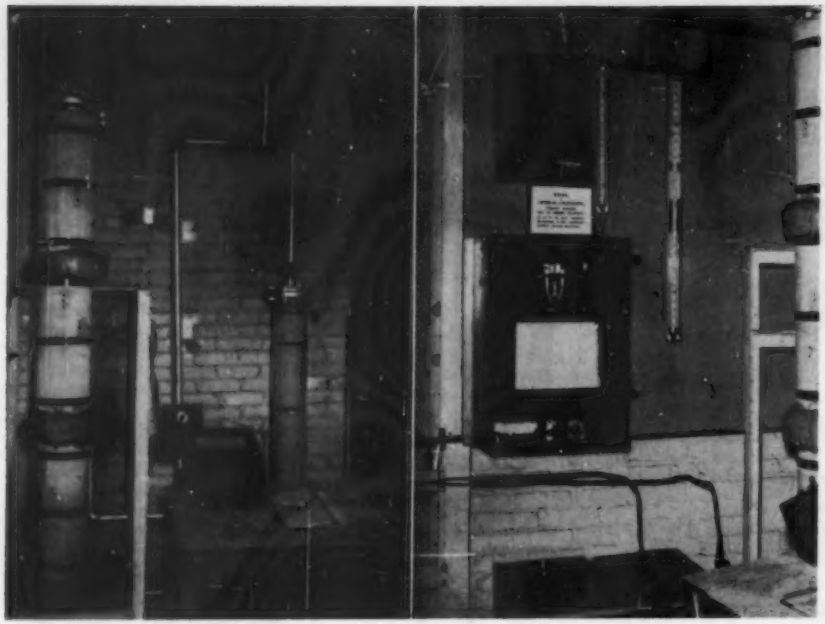


Figure 2 (left). A View of a Portion of the Experimental Apparatus.

Figure 3 (right). A View of the Manometers and Meter Run.

face area as the particle in question. For Cylinders

$$D_p = \left(D_c H_c + \frac{D_c^2}{2} \right)^{1/2} \qquad (4)$$

This tool has increased the scope of correlations because the pressure drop is some function of the surface area exposed to the flowing fluid.

Early Investigations. The first reported work on pressure drop was done by Zeisberg,[24] who measured the pressure drop through both wet and dry tower packings, and reached the conclusion that it was a function of the gas velocity squared. This was soon followed by Blake,[2] who, from the analogy with open conduits, concluded that

$$\frac{\Delta P \rho d}{LG} = C \left(\frac{dg}{\mu} \right) \qquad (5)$$

where d = the average diameter of the particles. No data were taken on solid particles but he reasoned that the average velocity through the packings should be used (G/f_t) and further that a bed could better be described by means of the surface area S rather than by diameter. Then,

$$\frac{\Delta P \rho f_t^3}{LG^2 S} = C \left(\frac{G}{\mu SF} \right) \qquad (6)$$

Gibson[12] developed by dimensional analysis an equation for open conduits

$$P = C\, V^n\, D_t^{n-1}\, \mu^{2-n}\, \rho^{n-1}\, L \qquad (7)$$

which can be applied to packings by considering the boundary limits. Obviously when

$f_t = 0$ $\quad \Delta P = \infty$
$f_t = 1.0$ $\quad \Delta P = 0.$

NOTATION

a = particle surface area per unit volume of bed.
A = wall effect factor, Proportional to D_p/D_t.
c = arbitrary constant.
C′ = arbitrary constant.
d = average particle diameter.
D_c = diameter of a cylindrical pellet.
D_p = equivalent diameter.
D_t = tube (chamber) diameter.
f = friction factor
f_t = fraction voids—dimensionless
f′ = modified friction factor
Fa = fractional effective free area
f_L = friction factor for loose arrangement of packing
f_d = friction factor for dense arrangement of packing
G = mass velocity — (normally lb./hr./sq. ft.)
g = gravitational constant
H_c = length of a cylindrical pellet
K = force per unit volume
L = depth of bed-ft.
P = pressure
ΔP = pressure drop—inches water
ΔP′ = pressure drop—lb./sq. ft.
S = surface area of a pellet
t = time
V = velocity—ft./sec. (based on empty cross-sectional area)
ν = kinematic viscosity
ρ = density
μ = dynamic viscosity
τ = shearing stress
ϕ = area-volume shape factor = $\frac{1}{\lambda}$

The term $\frac{1 - f_t}{f_t}$ is a correction factor satisfying the limits. This was added to Equation (7) by Burke and Plummer[6] to give an equation very similar to (6) which correlated well for lead shot, but did not cover a very wide range. In this approach n = unity for completely laminar flow, and n = two for completely turbulent flow.

Furnas[9,10] performed other work on beds of broken solids in both the laminar and turbulent flow regions. The effect of some of the variables, however, is difficult to determine.

Use of the Fanning Equation. Because of the number of variables present, it has been found expedient to use the modified friction factor as a means of correlation. If done with discretion this can result in a good correlation. The Fanning equation for conduits is:

$$\Delta P = \frac{2FLV^2\rho}{gD_t} \qquad (8)$$

Where the D_t/D_p ratio approaches 8.1 the volume between the particles is of the same order of magnitude as that of the particles. Chilton and Colburn[5] use this fact to convert Equation (8) for application to packed beds. Assuming that the predominant pressure loss is due to the alternate compression and expansion of the gas in the voids, and that this is fundamentally an orifice effect, they found equations for f' in terms of arbitrarily defined variables. This f' was then

plotted versus a modified Reynolds number to produce a fair correlation in both flow regions for the systems studied. By comparison with actual data they found that about ten percent of the loss was due to skin friction, and the remainder was the orifice effect. In the final analysis the correlation was of the form

$$\Delta P = \frac{2f' L G^2 A_t}{g\rho D_p} \qquad (9)$$

where A_t was an empirical constant which was a function of D_p/D_t, and was used to correct for the pressure loss adjacent to the tube wall.

Some correction such as A_t is necessary for in the region of the wall the geometry of the packing is such as to encourage a larger relative flow rate there, particularly where the packing is large in proportion to the tube diameter. A number of investigators, including Saunders and Ford[22] have measured velocities across beds and have found them to be within five percent of the velocity at the bed center, except within one particle diameter of the wall, where they were as much as 50 percent higher. This condition then not only affects pressure drop but in reality reduces solid-fluid contact, and thus fixes an effective limit on the size of packing that can be used in a given tube.

The work of Chilton and Colburn has been expanded by other investigators. Gamson, Thodos and Hougen[11] in their work on cylinders and spheres found that a plot of f' vs. D_pG/μ gave separate curves for each particle shape. It was also shown that when the particle surface was wet the pressure loss decreased. This factor introduces the effect of particle surface originally proposed and should not be confused with the case where liquid is flowing in the voids. In this case the surface was simply wet with liquid with all surplus drained off. Where the liquid is occupying some of the voids the pressure drop rises because the effective free opening is less. Some work in this regard has been done by White[23] in towers packed with Raschig rings. He omitted the wall effect factor since it was substantially constant in the size range of the packings investigated.

Oman and Watson[19] took cognizance of the fact that the same material will pack with a different percentage of voids as the packing procedure itself varies. In order to reproduce packing characteristics many investigators have used vibration, stacked the packing or dropped the material in a tube filled with liquid. A correlation is presented for a "dense" as well as a "loose" arrangement. For the former data the packing was added very slowly, allowing the individual particles to come to rest, while the latter data were obtained by inverting the chamber and suddenly righting it so that the bed fell as a mass.

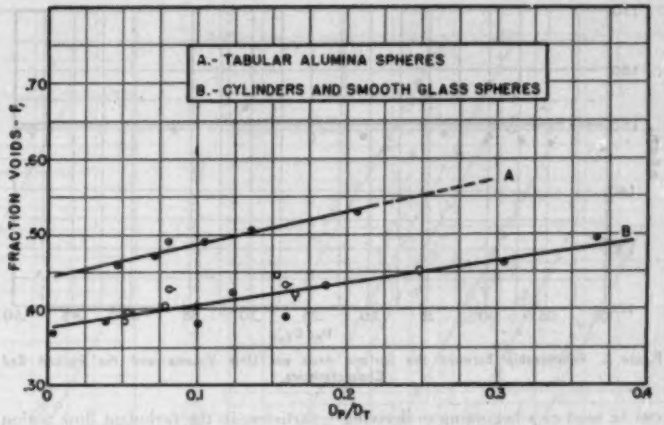


Figure 4. Fraction Voids in Beds of Particles in Cylindrical Chambers.

Another approach has been made to the problem by Rose[21] who used dimensional analysis to analyze the individual factors in isothermal liquid flow through granular materials. The functions found were obtained from cross plots of the data and indicated, in the range of particles studied, that they were primarily the same for both liquids and gases. The same type of packings were run by Allen[1] but his correlation was similar to previous friction factor equations.

The use of Packed Bed Characteristics. An examination of pressure drop factors should involve a more detailed examination of the effect of particle characteristics than has been used in many investigations. The flow most probably occurs through a series of main channels parallel to the chamber axis, the number of such channels depending primarily on the particle size. All cross flow which occurs might be considered analagous to free convection and results in certain regions of the packing having little resistance to the main flow. This effect, although almost impossible to predict in individual beds, would vary somewhat with the shape of the packing. For example, spheres tend to give open channels while cylinders sometimes align with the flat sides together and effectively block a channel. Cylinders also present a sharp edge to the flow which results in a sharper deflection in the gas and causes a higher loss in pressure. Such a bed might also exhibit a higher degree of cross flow.

It is also advisable to consider the effect of the particle surface upon the momentum loss. For laminar flow through conduits, the shearing of the layers of fluid over each other account for the principal pressure drop, while for turbulent flow it is a direct result of inertial factors. In packed beds the transition region shows no characteristic sharp breaks indicating that such inertial terms become of gradually growing importance. The "skin friction" or roughness of the particle surface then is a definite consideration in the turbulent flow region and obviously the more such area is exposed the larger is the pressure drop to be expected. This tends to confirm such correlations as that of Carman.

An attempt has been made by Brownell and Katz[3,4,5] to include such factors as these in the prediction of pressure losses. This is done by plotting a friction factor versus Reynolds number, where the latter is defined by:

$$Re = \frac{D_p G}{\mu f_v m} \qquad (10)$$

where m = exponent of porosity depending on the shape of the particles and the porosity of the bed.

The friction factor is defined by

$$f' = \frac{2\varepsilon D_p \Delta P f_v^n}{LV^2} \qquad (11)$$

where n = exponent of porosity depending on the shape of the particles and porosity of the bed.

A shape factor known as the sphericity was also introduced and used to determine the constants m and n. The sphericity in turn was determined from an average diameter. This work checks previous investigators where the percentage voids is about forty percent.*

The dimensional analysis of the flow of fluids through an empty tube

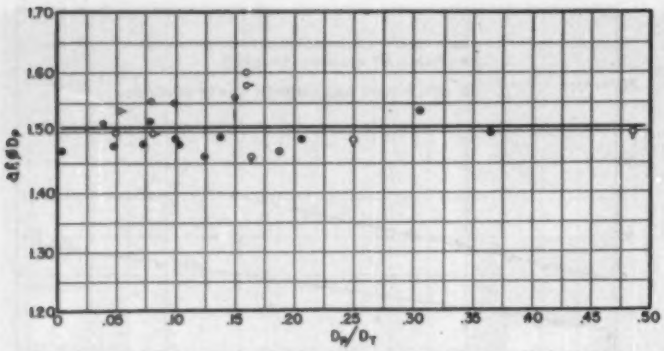


Figure 5. Relationship Between the Surface Area per Unit Volume and the Packed Bed Characteristics.

can be used as a beginning in deriving an expression for those chambers containing a packing material. The following equation, or its equivalent may be found in texts dealing with fluid mechanics.

$$\Delta P = \frac{\rho V^2 L}{g D_t} \int \frac{D_t V \rho}{\mu} \qquad (12)$$

From dimensional analysis and the examination of experimental data this may be written

$$\Delta P = \frac{k' \rho V^2 L}{g D_t} \left(\frac{D_t V \rho}{\mu} \right)^{n-2} \qquad (13)$$

where n is a function of the state of flow and k' is an arbitrary constant. Separation of the variables yields

$$\Delta P/L = \frac{k'}{g} (\mu^{2-n}) (\rho^{n-2}) (V^n) (D_t^{n-4}) \qquad (14)$$

Several investigators have modified this equation to apply it to packed bed pressure drop.

Leva[15, 16, 17] performed work on both smooth and rough particles of various shapes and derived equations which were verified by his data. For smooth particles, in the turbulent flow region he has proposed

$$\Delta P' = \frac{3.50\, G^{1.9}\, \mu^{0.1}\, L\, (1 - f_t)}{D_p^{1.1}\, g\, \rho\, \phi^{1.1}\, f_t^{\,3}} \qquad (15)$$

Hatch[18] has also used a modification of Equation 19.

Experimental Work

In order to extend and check the existing literature a variety of common spherical and cylindrical packing materials were investigated. The test chambers were made of 2, 4 and 6-inch standard pipe in sections 3, 4 and 6-feet in height respectively. The packing specifications are shown in Table 1. Natural gas from commercial mains was used as the fluid and varied in specific gravity from 0.53 to 0.76 among the various runs.

The data were easy to obtain but extreme care had to be exercised in packing the chambers in order to obtain reproducible results. A number of packing schemes were tried which gave widely varying packing characteristics until it was decided to use a procedure comparable to that normally encountered in industrial units. The material was poured very slowly into the chamber, accompanied by periodic light taps of a hammer on the sides in order to help align the packing. The resultant arrangement, which might be called one of medium density with regard to porosity, settled very little during the course of a run indicating that it was reasonably stable. The packing characteristics shown in Table 1 were obtained in this manner and are the result of three check measurements. Data such as specific heat and thermal conductivity were obtained from the manufacturer. The dimensions of the particles were determined on not less than lots of 50 selected at random from the screened commercial packing. A micrometer was used for all measurements with three diameters being taken on the spheres, and two diameters and a length on the cylinders. These readings were then averaged.

The percentage voids was obtained by two methods. In one a known volume of pellets was weighed and the voids calculated from the absolute density. In the other the pellets were packed in dummy chambers 2, 4, and 6 inches in diameter and water added. The volume of the water was noted, and since the total volume was known the voids could be computed. Since several of the packings were porous, they were soaked for several days prior to this test to fill the interstices. They were then surface dried with a cloth before being placed in the test cell. Excellent checks were obtained between the two methods. The surface area per cubic foot of bed volume was calculated from the particle dimensions and the packed bed density.

Packing Characteristics

A packing material may align itself in a bed in several geometric arrangements. By systematically stack-

* In a later article this correlation has been revised. Chem. Eng. Progress, 46, 415 (1950).

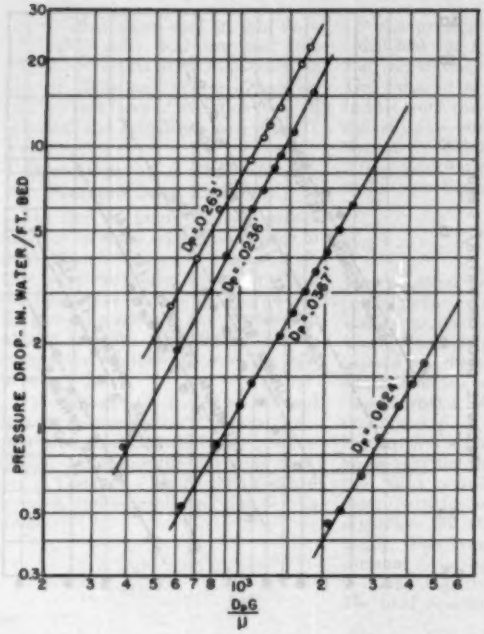
TABLE 1
Packing Material Specifications

	Chamber Diameter	Silica Alumina	Hydrated Alumina	Abrasinum	Tabular Alumina	Aluminum	Glass	Glass	
Shape	..	Cylinder	Cylinder	Sphere	Cylinder	Sphere	Cylinder	Sphere	Sphere ¶
Dimensions—Inches	..	0.155x	0.255x	0.283	0.253x	0.440	0.501x	0.75	1.0
	..	0.165	0.264		0.291		0.533		¶
D_p*	..	0.0102	0.0263	.0236	.0271	.0367	0.0524	.0624	.0833
Thermal Conductivity°	..	0.62†	0.63†	1.8†	117	1.8†	117	0.63	0.63
Heat Capacity–C_p	..	0.23	0.23	0.20	0.21	0.20	0.21	0.20	0.20
No. of part. per $ft.^3$	2"	331,000	70,900	71,900	67,400	18,200	8810	3900	1600
No. of part. per $ft.^3$	4"	344,000	76,000	74,000	67,000	19,600	9970	4480	1810
No. of part. per $ft.^3$	6"	349,000	78,600	78,700	70,900	20,450	10,150	4540	1910
Surf. Area per $ft.^3$	2"	270	153	125	158	76.4	74.0	67.6	34.9
Surf. Area per $ft.^3$	4"	280	164	129	154	82.3	84.8	54.7	39.4
Surf. Area per $ft.^3$	6"	284	170	137	163	85.9	98.3	55.4	41.7
Packed Dens. $lb./ft.^3$	2"	38.3	51.3	121	93.1	115	87.4	76.4	74.8
Packed Dens. $lb./ft.^3$	4"	39.8	55.0	125	95.3	125	98.8	87.5	84.2
Packed Dens. $lb./ft.^3$	6"	40.4	56.1	133	97.6	130	101	88.9	89.1
Absolute Dens. $lb./ft.^3$		64	92.7	245	162	245	163	154	154
Percent Voids	2"	40.1	44.6	50.6	43.3	53.0	46.4	50.4	51.5
Percent Voids	4"	37.7	40.6	49.1	42.9	49.1	39.4	43.2	45.4
Percent Voids	6"	36.8	38.5	45.9	40.1	47.0	38.1	42.3	42.1

* Equivalent diameter $(D_p) = \left(D_c H_c + \frac{D_c^2}{2} \right)^{1/2}$ for cylinders

† Estimated

°Btu. — ft. per $ft.^2$ — °F. — hr.



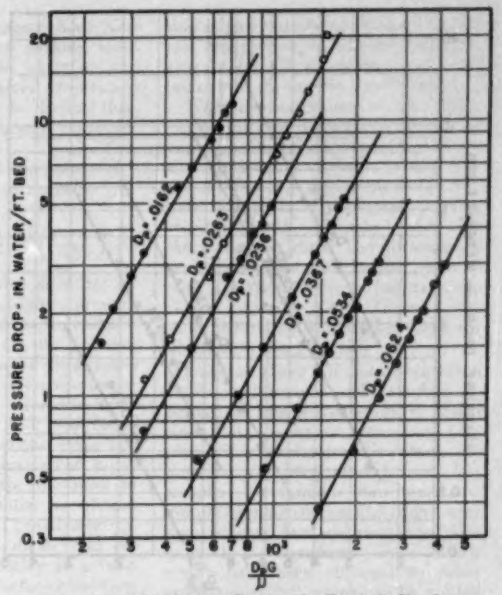


Figure 6 (at left). Pressure Drop in the Two-Inch Chamber.
Figure 7 (above). Pressure Drop in the 4-Inch Chamber.

ing spheres, it is possible to obtain either a cubic or various forms of an orthorhombic configuration. The former gives the maximum amount of voids with spheres, while the latter results in a minimum. The latter configuration can also be broken down into several sub-groups distinguished by the angle of repose between individual particles. For spheres, the cubic system is not stable because packing pressure tends to force the particles into an orthorhombic pattern. The average bed is built up by random dumping. All of these configurations may therefore exist together at one time and vary from bed to bed. In light of this fact, it is necessary to predict the bed characteristics on some basis other than geometric. Due to the uncertainty which exists because of the random nature of the distribution, a general correlation of data becomes difficult.

Prediction of the Fraction Voids. The volume of void space in a bed is a principal variable. As the gas flows, it undergoes a series of compressions and expansions as it squeezes between the particles and then expands into the voids. Since this process is not reversible, in the thermodynamic sense, it accounts for a large percentage of the total energy loss. In addition, the flow might be compared to that of a fluid flowing through a series of irregular conduits in parallel and thus it follows, all other factors remaining the same, that the larger the voids the less the pressure drop expected. A mathematical analysis of the configurations for spheres indicates that the percentage voids should be between 26 and 49 percent. However, in the normal range of fixed bed particle sizes, with random dumping, the lower value is seldom if ever reached while the higher value is often exceeded. In effect, the range of void volume is just displaced upward, for random dumping if done rapidly will cause voids which are in many cases larger than the particles. In addition, the theoretical percentages make no allowance for the larger void volume which exists in the vicinity of the container wall.

Several of the variables which affect pressure drop in other ways also are a function of the percentage voids. Obviously, the larger the particle the larger the percentage voids, if only geometry is considered. Also, the shape must be considered, for spheres pack less than cylinders since they make only point contacts. Cylinders, on the other hand, have flat surfaces which can align and effectively reduce the amount of open spaces. This is shown in Table 1 for in every case the cylinders gave from four to six percent less void space than the spheres.

Surface roughness is also a variable when random packing is used. The materials with a rougher surface have a higher degree of skin friction which lets them assume a stable configuration with more free space. The smoother particles produce a smaller volume of voids, particularly if the system undergoes any vibration. Surface roughness is not quite so important if the packing is stacked since the configuration is stable at the outset.

Another factor which has shown a marked effect is the packing arrangement in the vicinity of the container wall. Here the configuration is conditioned by the wall and results in a higher void volume. Geometric similitude shows that this volume adjacent to the wall is a function of particle shape and the ratio of particle diameter to tube diameter. This factor is of utmost importance for gas may channel along the wall and cut down the degree of effective fluid-solid contact.

A fifth variable enters when the packing consists of a mixture of particles having different diameters. The small particles tend to occupy the voids created by the large ones, with a consequent reduction in the fraction voids. However, in this work only particles of uniform size were used.

It is convenient in heat transfer and pressure drop studies to define shapes of irregular particles in terms of an equivalent particle diameter (D_p). This is defined as the diameter of a sphere that would have the same surface area as to the particle in question. Equation 4 gives the value for cylinders.

In an attempt to correlate percent voids, the values shown in Table 1 were plotted versus the ratio of parti-

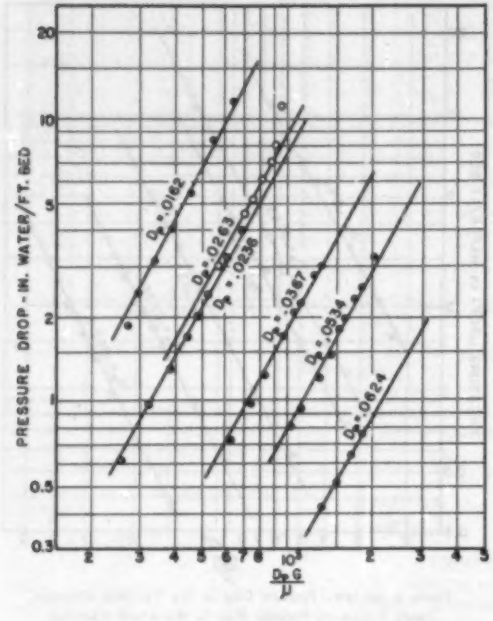


Figure 8. Pressure Drop in the 6-Inch Chamber.

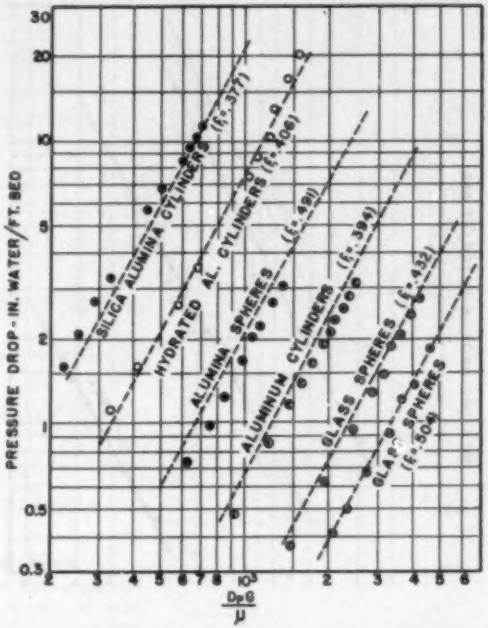

PRESSURE DROP - IN. WATER/FT. BED
SILICA ALUMINA CYLINDERS (f_t = .377)
HYDRATED AL. CYLINDERS (f_t = .406)
ALUMINA SPHERES (f_t = .491)
ALUMINUM CYLINDERS (f_t = .394)
GLASS SPHERES (f_t = .432)
GLASS SPHERES (f_t = .504)
$\frac{D_p G}{\mu}$

Figure 9. Comparison of Calculated and Observed Pressure Drops.

cle to tube diameter as shown in Figure 4. Two lines were drawn through those points representing the data. At least two lines are expected in view of the factors discussed above. Line *A* correlates the data for tabular alumina spheres which are rougher than the glass spheres. The latter fall on line *B* along with the cylinders. Unfortunotely, no criterion for the degree of surface roughness exists. In fact, none that would offer practical usage seems probable, for it would involve irregular projections as well as true surface friction.

The effect of surface shape is shown by the higher void volumes exhibited by the spheres. The spread of points at the lower diameter ratios may be attributed to the differences in surface roughness. The silica-alumina particles were somewhat irregular, while those of hydrated alumina were relatively smooth. With the aluminum cylinders the surfaces were quite smooth but the method of manufacture left ragged edges. All of these factors contribute to the spread.

The slight upward slope shows the influence of the wall effect. Although this correlation cannot be considered general, it gives results which are typical of catalytic and heat transfer materials, and is suitable for estimation purposes. For tabular alumina spheres

$$f_t = 0.435\ D_p/D_t + 0.442 \qquad (16)$$

For cylinders (and very smooth spheres)

$$f_t = 0.308\ D_p.D_t + 0.373 \text{ where}$$
$$f_t = \text{fraction voids.} \qquad (17)$$

Correlation of Particle Surface Area. This particular characteristic is of importance not only for pressure drop but also in relation to heat transfer. Some pressure loss is due to skin friction. Obviously, the larger the surface exposed the more such loss should be expected. The area data from Table 1 were plotted versus the D_p/D_t ratio. A series of substantially parallel lines, having slight negative slopes, were obtained. The surface area per unit volume, however, is inversely proportional to the size of the particle and the percentage voids. The introduction of these factors resolved the data into two lines, one for spheres and one for cylinders, the latter having the higher value. This was expected, for a sphere is that geometric shape which has the least area per unit volume. Therefore, some area-volume factor was a logical addition to the correlation. One such factor has been defined by Leva[18] and it was found that inclusion of this term (ϕ) brought the lines together. For the cylinders used $\phi = 0.87$ while for spheres $\phi = 1.0$. Since a cylinder has the greater surface area of the two, the surface area per unit volume (a) should be inversely proportional to this factor, or

$$a \propto \frac{1}{D_p f_t \phi} \qquad (18)$$

The surface area factor $aD_p f_t \phi$, which is dimensionless, was plotted versus the particle diameter to tube diameter ratio as shown in Figure 5. A group of points lying parallel to the abcissa (D_p/D_t) were obtained. For the most part these had a value between 1.46 and 1.56 with an arithmetic average of 1.51. The equation of the line through these points is

$$a = \frac{1.51}{D_p f_t \phi} \qquad (19)$$

which gives a correlation, for the packings studied, that is within ± 7.0 percent of the most extreme points. This correlation is not subject to such factors as surface roughness except as they affect the fraction voids. Therefore, once the fraction voids has been accurately determined Equation 19 should apply. No attempt has been made to extend its use to other than cylindrical and spherical particles. However, it was compared with the surface area measurements of another investigator[20] for Wilcox sand and gave values within 11 percent. This is particularly good when it is realized that the sand particles are much

smaller than those used in this work (150-200 mesh) and are not true spheres. It would thus seem valid to propose Equation (19) as a satisfactory surface area correlation for all spherical and cylindrical particles.

Derivation of a Theoretical Pressure Drop Equation

The flow of fluids through porous media is in many respect analogous to that through an empty tube. Therefore, it is convenient to reason from the latter type of flow in determining the general magniture and relationship of the variables. Equation (13) expresses the relationship used for flow in empty tubes.

For packed beds it has been found that the pressure drop P is some function of a modified Reynolds number D_pG/μ. Replacing the Reynolds number in Equation (13) by this modified number, and remembering that $G = V\rho$ gives

$$\Delta P/L = \frac{\rho V^2}{gD_t} C \left(\frac{D_p V \rho}{\mu}\right)^{n-1} \quad (20)$$

or

$$\Delta P/L = \frac{C}{g}(\mu^{2-n})(\rho^{n-1})(V^n)(D_p^{n-2}) \quad (21)$$

The boundary conditions for a packed bed are

$$f_t = 0 \quad \frac{\Delta P}{L} = \infty$$

$$f_t = 1.0 \quad \frac{\Delta P}{L} = 0$$

If Equation (21) is multiplied by the factor $1 - f_t/f_t^m$ it will satisfy these conditions. Rearrangement and the addition of this term to Equation (21) gives

$$\frac{\Delta P}{L} = \frac{C\mu^2}{g\rho D_p^3}\left(\frac{D_p G}{\mu}\right)^n \frac{1 - f_t}{f_t^m} \quad (22)$$

As shown in Figures 6, 7 and 8 $\Delta P/L$ was plotted on log-log paper versus D_pG/μ, for each packing in each of the three chambers. For a given material in any one chamber the first and last terms on the right hand side of Equation (22) are constant, which means that the slope of the lines gives the proper value for n. It was noted that all the lines were substantially parallel and had an average slope of 1.85, regardless of the chamber diameter. Therefore, $n = 1.85$ in Equation (22).

An examination of the lines in the three figures also shows that the pressure drop for a given packing varies with chamber diameter due to the difference in the percentage voids. The last term in Equation (22) accounts for this variable. It was found that when $m = 3$ in the expression $1 - f_t/f_t^m$ the pressure gradient lines were coincident for a given packing material, regardless of the chamber size. The value of m obtained empirically in this work can also be derived theoretically for spheres from a consideration of the geometry.

The substitution of the values of n and m into Equation (22) yields

$$\Delta P/L = \frac{C\mu^2}{g\rho D_p^3}\left(\frac{D_p G}{\mu}\right)^{1.85}\left(\frac{1 - f_t}{f_t^3}\right) \quad (23)$$

This equation, however, does not account for two of the variables present: surface roughness and particle shape. Visual examination of the particles showed that there were different shapes which had the same relative surface characteristics. With reference again to Figures 6, 7 and 8, it was found that the introduction of the shape factor ϕ into the denominator of Equation (23) would make the lines of those particles of similar roughness, regardless of shape, practically coincide. This would indicate that the constant C in the equation is a function only of particle surface condition. The final equation is then:

$$\frac{\Delta P}{L} = \frac{C\mu^2}{g\rho D_p^3\phi}\left(\frac{D_p G}{\mu}\right)^{1.85}\frac{1 - f_t}{f_t^3} \quad (24)$$

In order to determine values of C the observed pressure drop for a given value of the modified Reynolds number was substituted into Equation (24). The remainder of the terms were then evaluated from the fluid and packing characteristics which gave a solution for C. The following coefficients were obtained.

MATERIAL	C
Smooth Spheres	0.66
Silica-Alumina Cylinders	0.76
Hydrated Alumina Cylinders	1.35
Aluminum Cylinders	1.10
Tabular Alumina Spheres	1.76

This compilation shows further that C is primarily a function of surface conditions, for the same material of different diameters had the same value of C. Unfortunately, no criterion for this constant exists other than visual examination. However, the more common types of packing materials used in heat transfer have been evaluated in this work as a guide for the prediction of this value.

The comparison of the calculated pressure drop with the observed data is shown in Figure 9. The data points shown were selected at random from Figures 6, 7 and 8 and represent different shapes, materials and bed porosities. This plot shows that Equation (24), with the proper value of C, gives a good prediction of the pressure gradient to be expected. The correlation is particularly applicable to process design for it utilizes variables (except for C) which are readily obtainable from process specifications.

With the exception of the coefficients and the powers to which the variables are raised, Equation (24) is almost identical in form to one proposed by Leva.[15] Inasmuch as the data were obtained on different packing materials with different fluids the check is rather close. The difference in exponents might well be the result of some variations in experimental technique. Equation (24), however, extends the range of chamber sizes for which data are available.

Laminar Flow. All data were taken under conditions of turbulent flow inasmuch as this is the region in which most heat exchange processes take place. The mechanism by which the pressure drop takes place is much less complex for laminar flow since the compression-expansion and eddy losses are reduced. Surface roughness also ceases to be significant. Data in this region have been obtained by other investigators[7, 8, 15] which can be plotted as a modified friction factor versus the modified Reynolds number used here.

In the transition region between laminar and turbulent flow no reliable correlation has been developed. In this region it would be advised to obtain data for each specific system.

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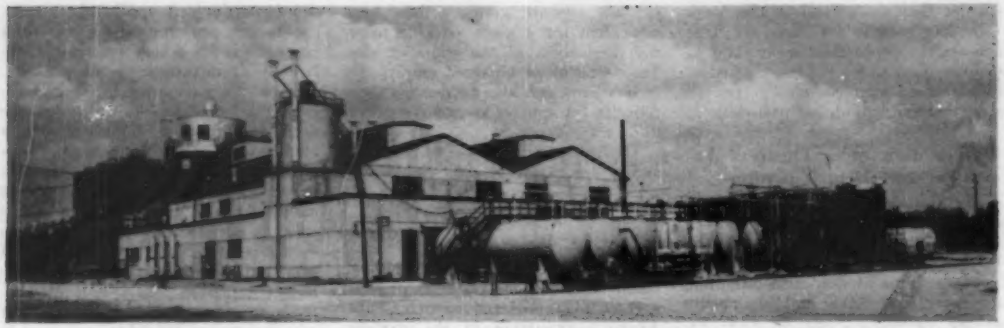


Cyanamid's Michigan City Plant for Production of Synthetic Microspheroidal Cracking Catalysts. A General View Looking Past the Raw Material Storage, Process Building, Spray Dryer and Finished Product Storage.

New Synthetic Catalyst Plant To Supply 450,000 BPD Cracking Capacity

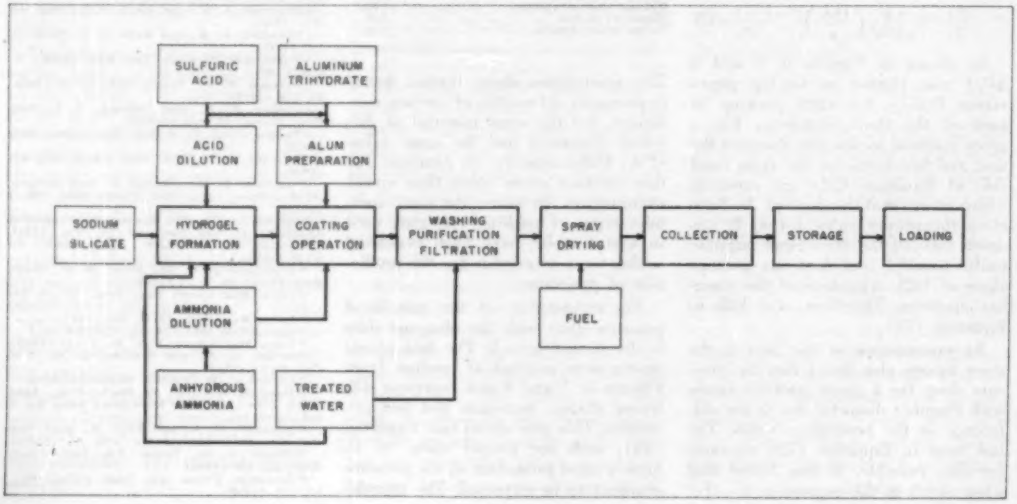
G. L. GLESPEN

American Cyanamid Company, New York

PARALLELING the development of high-octane gasolines has been the auxiliary development of synthetic cracking catalysts. Refiners, keeping stride with the rapid developments in catalytic processes, will be interested in the new plant built by American Cyanamid at Michigan City to manufacture microspheroidal, silica-alumina cracking catalyst.

WITH the pressing demand for high-octane gasoline, the position of catalytic cracking processes has reached a new level of importance in the refining industry. According to the Petroleum Administration for Defense, the industry's expansion will add up to an additional catalytic cracking potential of 750,000 barrels per day. While the refiner is making rapid progress in the development of these processes, new advances

Process Flow Diagram Showing Essential Steps in Manufacture of Synthetic Microspheroidal Catalyst.



are also being made in the manufacture of synthetic catalysts. The newest development in this field is the plant built by American Cyanamid at Michigan City for the manufacture of microspheroidal, silica-alumina cracking catalysts. Completed in September of this year, the plant will ultimately be expanded to produce fluid catalyst sufficient for 450,000 barrels per day of fluid cracking capacity, bringing the company's total production (counting its other catalyst plant in Fort Worth, Texas) to a level sufficient for 1,030,000 barrels per day. The final cost of the new plant is expected to exceed $5 million.

Occupying a 90-acre site near Lake Michigan, the plant location affords dependable transportation service by rail and by truck. The plant features a continuous flow pattern in a northerly direction from the raw material unloading area to the finished product loading area. Raw materials, unloaded on the southern spur of the adjacent railroad, flow through the process building, spray drier, collector system, and finally to storage silos where the finished product is loaded in hopper cars on the northern spur.

Basically, the process consists of precipitating alumina on a previously prepared silica gel. The resulting silica-alumina combination is then purified and dried. The finished catalyst, a fine powder, consists of a silican network containing active alumina centers dispersed on a large surface area. The average particle size of the fine grade is approximately 40 microns, while that of the coarser type is 60 microns.

The Hydrogel Is Precipitated in These Wooden Process Tanks.

Rotary Vacuum Filters Used to Remove Soluble Salts and Impurities. Spray Nozzles for Washing Are Shown at Left.

Raw Materials

The basic raw materials involved in the process are sodium silicate, aluminum trihydrate, sulfuric acid, demineralized water and anhydrous ammonia. The sodium silicate, arriving by tank car, is pumped directly to storage, requiring no preparation for the initial processing step. Anhydrous ammonia, used throughout the process for pH control, is allowed to expand from tank cars into diluting tanks to the correct concentration. Water, used at the rate of 15,000 gallons per ton of finished catalyst, is processed from city water in a resin-type ion exchange bed before being used in the process, where a demineralized and sodium-free water is required.

Preparation of aluminum trihydrate for processing is accomplished in an unusual system whereby the material is completely enclosed while flowing from the hopper car to the dilute solution tank. The aluminum trihydrate, discharged from the hopper car, is air-conveyed to the storage silo from which it descends through a weigh hopper to a digester. After being treated with acid and diluted to concentration strength, the alum settles and is pumped to the process. The elaborate enclosure system is deemed necessary from the standpoint of operators' protection.

Process Flow

The accompanying flow diagram illustrates the essential steps in the process. The real beginning of the process is the silica hydro-gel formation, which is one of the most important steps in obtaining the desired catalyst surface characteristics. The formation of the gel is accomplished by the addition of water and sulfuric acid to sodium silicate with the pH being controlled by ammonia. The formation mechanism involves a system of lattices of alternate silicon and oxygen molecules with hydrogen atoms further attached to the silicon. The interstices of the lattice work form pockets which are filled with water at

the gel stage. These pockets form the vast network of pores which give the dried catalyst a surface area of 55 acres per pound.

The second step in the process is the coating of the gel with alum. This addition of alum precipitates an alumina gel throughout the silica gel grains. The washing-filtration step to which the gel slurry next passes frees the catalyst of soluble salts and impurities. Filtration is accomplished with rotary, vacuum-type filters, possibly the world's largest application of this filter type.

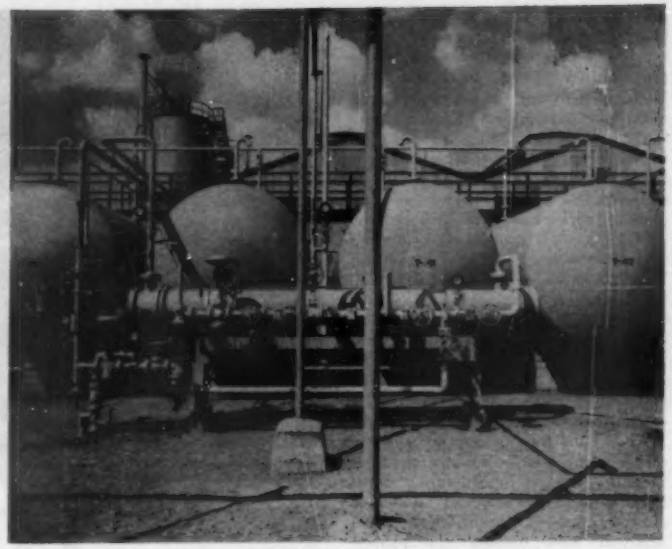
In the final step the slurry is sent to the spray drier to be atomized and dried. The atomization forms the minute round droplets or microspheres and determines the particle size range of the product. The slurry is introduced in the upper part of the spray chamber and the product is separated from the hot gases by banks of cyclone separators and is air-conveyed from a common hopper to storage.

Auxiliary Facilities

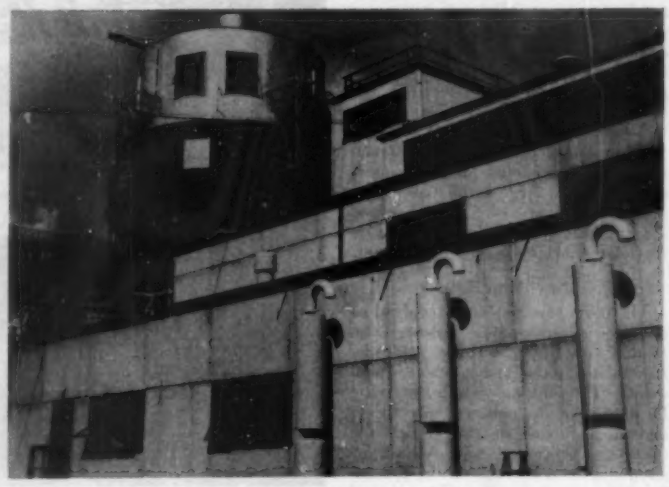
Waste heat is recovered from the spray drier stack gases by an exchanger used to preheat the process water. Although the waste water contains nothing more harmful than sodium and ammonium sulfates, a unique system of waste disposal has been developed at the request of the Indiana State Board of Health. An injection well was drilled to an underground stream. After most of the solids have been removed the waste water is pumped into the underground stream. This aquifer has been found in tests to have an ample capacity for the volume of waste effluent.

A high degree of quality control is maintained by sampling process streams at all critical points for analysis in the laboratory. In order to assure uniform activity of successive shipments samples are checked against a standard in an actual cracking test. The finished product is tested for alumina and moisture content as well as for impurities such as iron and sodium. Of paramount importance is the particle size range. Spray drier conditions are changed to give various grades of synthetic catalyst. The finer grade is designed for fluid cracking units with precipitators while the coarser grade is manufactured for use in units having no secondary recovery systems.

Advantages of the synthetic catalyst, resulting from the controlled particle size, are its superior fluidization and low erosivity of equipment. Its thermal stability and ability to withstand steaming make possible a catalyst life of 11,000 contacts during an average residence time of 150 days.



Automatic Ammonia Dilution Equipment and Storage Tanks.



Spray Dryer Installation with Process Building in Foreground.

* * *

Introduction to Chemical Reaction Calculations

Part III.

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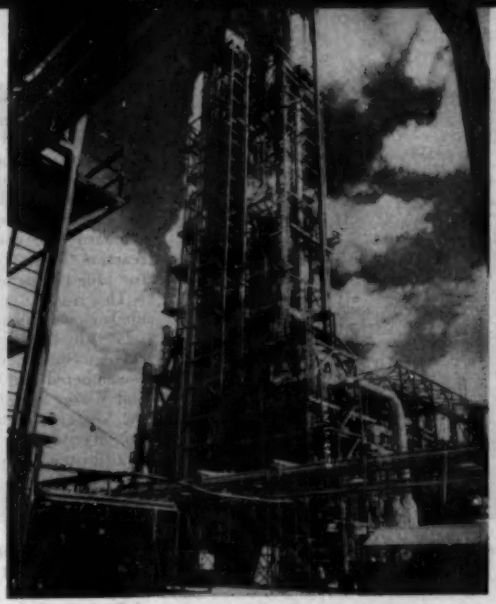


Thermofor Catalytic Cracking Unit with Catalyst Circulation by Airlift.

IN THE preceding article in this series, equations were developed for isothermal, isometric (constant volume) second order chemical reactions. Example 13 showed the use of some of these equations. Example 14 will further illustrate these points.

Example 14: In the reaction of Example 13, how much *A* will be reacted in 30 minutes if stoichiometric feeds are employed, two mols of each reactant being added, at the start of the reaction. Temperature and initial pressure remain the same as before.

Solution: Since equivalent feeds are used, Equation 56 is applicable.

$N_{Af} = N_{Bf} = 2.00$

$V = 1950$ ft³, from Example 13, since same number of mols charged.

$$k = (V/\theta)\,(N_{Af} - N_{Ao})/(N_{Ao}\,N_{Af})$$

$$35.7 = (1950/30)\,(2.00 - N_{Ao})/(N_{Ao}\,2.00)$$

$$1.13\,N_{Ao} + N_{Ao} = 2.00$$

$$N_{Ao} = 0.94$$

Thus, 1.06 mols A have reacted.

Another common method of presenting these equations is in terms of the amount of material consumed, x_A:

$$x_A = N_{Af} - N_A$$

$$N_A = N_{Af} - x_A$$

$$dx_A/d\theta = -dN_A/d\theta \quad \ldots\ldots (57)$$

Equation 57 is obtained by differentiating the previous equation, with respect to θ. Using Equation 57, the second order, irreversible, isothermal, isometric, equivalent feed equation, Equation 55:

$$-dN_A/d\theta = k\,N_A^2/V$$

$$dx_A/d\theta = k\,(N_{Af} - x_A)^2/V$$

Separating the variables and integrating,

$$dx_A/(N_{Af} - x_A)^2 = k\,d\theta/V$$

$$[1/(N_{Af} - x_A)] - [1/N_{Af}] = k\theta/V$$

$$x_A/(N_{Af})\,(N_{Af} - x_A) = k\,\theta/V \quad \ldots (58)$$

If Equation 50 is to be integrated under isobaric conditions, rather than isometric conditions, the integration must account for possible variations in volume. This is accomplished by defining a term, α, which is the change in volume of the system per mol of *A* reacted. For a perfect gas system,

$$\alpha = \Delta V/\Delta N_A = \Delta n RT/\pi$$

$$V = V_o + \alpha(N_{Af} - N_A) \quad \ldots\ldots (39)$$

Isobaric processes usually occur in a flow system; thus, Equation 35 will again be used to relate concentration of reactant, *A*, to reactor volume rather than time. From Equation 50,

$$-dN_A/d\theta = k\,N_A\,N_B/V$$

$$-V^2\,dN_A/(N_A\,N_B) = k\,dV_B \quad \ldots (59)$$

Remembering that $N_B = N_{Bf} - (N_{Af} - N_A)$ . . . . . (51)

CONTINUING FROM the preceding article in this 3-part series, (Part II in the October issue), examples of calculations are given and pertinent equations outlined for some of the more complicated types of non-catalytic reactions. In catalytic reactions, allowances must be made for mass transfer and diffusion, as well as chemical reaction rate considerations. A discussion of these factors, as well as other pertinent solid catalyst aspects, concludes this series.

the integrated form becomes

$$(N_{Af} - N_{Ao}) + \left[\frac{(V_o + \alpha N_{Af})^2}{(N_{Bf} - N_{Af})\alpha^2}\ \ln (N_{Af}/N_{Ao})\right] + \left[\frac{(V_o/\alpha + N_{Bf})^2}{(N_{Bf} - N_{Af})}\ \ln (N_{Bo}/N_{Bf})\right] = k\,V_R/\alpha^2 \quad \ldots\ldots (60)$$

Again it will be noted that the equation becomes indeterminate for stoichiometric or equivalent feeds. Using the fact that $N_A = N_B$ at all times for equivalent feeds, Equation 59 becomes:

$$-(V^2\,dN_A)/(N_A)^2 = k\,dV_R \quad \ldots\ldots (61)$$

$$(N_{Af} - N_{Ao}) + [(V_o + \alpha N_{Af})/\alpha]^2\,(1/N_{Ao} - 1/N_{Af}) - 2\,[(V_o + \alpha N_{Af})/\alpha] \ln \left(\frac{N_{Ao}}{N_{Af}}\right) = k\,V_R/\alpha^2 \quad \ldots\ldots (62)$$

An example of the use of Equation 62 follows:

Example 15: The reaction, $A + B \rightarrow 3C$, is carried out in a bomb at 572° F., and the reaction is found to be second order. k at at this temperature is 2,575 ft³ hr^{-1} mols^{-1}. It is desired to treat 10,000 cubic feet per hour of feed gases at 32 atmospheres absolute pressure and 572° F., the feed gas consisting of 45 percent A, 45 percent B, and 10 percent inerts. Ninety-five percent of A is to be converted. It is known that for this system the ideal gas law holds fairly well at the above pressure, and temperature. Calculate the internal volume of the reactor required.

Solution:

$a = \Delta nRT/\pi = 1 \times 10.73 \times 1032/(32 \times 14.7) = 23.60$

$a^2 = 556.5$

N_P (total mols) $= V_t/a = 10{,}000/23.60 = 424$

$N_{Af} = 424 \times 0.45 = 190.8$

$N_{Bf} = 190.8$

Inerts $= 42.4$

$N_{Ao} = 190.8 \times 0.05 = 9.54$

Substituting in Equation (61)

$(424 + 190.8)^3 (1/9.54 - 1/190.8) - 2(424 + 190.8) \ln 20 + 181.3 = \frac{2575\ V_R}{556.5}$

$4.62\ V_R = 37{,}700 - 3{,}690 + 180$

$V_R = 7{,}400\ ft^3$

Another method of expressing the integrated equation for k is in terms of the fraction of component A converted, x_C. For equivalent isometric feeds,

$$x_C = (N_{Af} - N_A)/N_{Af}$$
$$N_A = N_{Af}(1 - x_C)$$
$$-dN_A/d\Theta = N_{Af}(dx_C/d\Theta) = k(N_{Af})^2 (1 - x_C)^2/V$$

Separating variables and integrating,

$$1/N_{Af}[x_C/(1 - x_C)] = k\Theta/V \quad \ldots \quad (63)$$

Of the three types of equations presented (in terms of N_A, x_A, or x_C), the one which will be most useful depends on the form of the experimental data. In the opinion of the writers the type equations employing the effluent numbers of mols, N_{Ae}, is usually the most versatile in application. Knowing N_{Ae}, the reactants consumed and the conversion may be readily calculated from the relationships,

$$x_A = N_{Af} - N_{Ae}$$
$$x_C = (N_{Af} - N_{Ae})/N_{Af}$$

The dimensions of k in these equations is the same in all the derived equations, $ft^3\ mols^{-1}\ min^{-1}$, as previously shown. Values of k in dimensions other than these should be converted to the appropriate form before use. Equations 21 to 26 may be used for this purpose.

A large number of industrial reactions occur in such manner that the reaction products combine and form the original reactants. This type of reaction is known as a reversible reaction, and calculations involving a reversible reaction must be handled in a different manner from the irreversible reactions previously considered. It is customary to assume that each of the reactions takes place at its own specific rate, independently of the others occurring simultaneously. Each reaction also follows the rate equation for its own particular order. Thus, the total net change in the system may be found by summing the changes caused by each independent reaction. In addition to reversible reactions, consecutive reactions and concurrent or side reactions also may occur. Of course, complex combinations of these three categories may also occur.

Calculations concerning reactions of the reversible type are complicated by the fact that maximum conversion levels are limited by both the size of the reactor proper and also by the thermodynamic equilibrium yield. The equilibrium yield or degree of completion may be determined from the standard free energy change for the reaction. It may be less than 5 percent, for plus values of $\Delta F°$.

The reaction velocity constants for the forward and reverse reactions are related by the thermodynamic chemical equilibrium constant. It will be remembered that the law of Guldberg and Waage stated that the velocity of the forward reaction was equal to the velocity of the reverse reaction at equilibrium. From this statement certain expressions were formulated, resulting in the following equation:

$$K_e = K_1/K_2 = e^{-\Delta F°/RT} \quad \ldots \quad (64)$$

Treatment of reversible reactions is based on the fact that the net velocity of reaction is given by the difference of the forward and reverse velocities. Derivation of the more common isothermal-isometric cases are presented below. It is a simple matter to extend this treatment to other cases. For the Forward first order—Reverse first order.

$$A \rightleftharpoons B$$
$$-dN_A/d\Theta = k_1 N_A - k_2 N_B$$

Assuming $N_B = 0$ at $\Theta = 0$,

$$N_B = N_{Af} - N_A - \frac{dN_A}{d\Theta} = k_1 N_A - k_2$$
$$(N_{Af} - N_A) = (k_1 + k_2)N_A - k_2 N_{Af}$$

Separating the variables and integrating,

$$\int_{N_{Af}}^{N_{Ae}} -dN_A \left\{ 1/[(k_1 + k_2)N_A] - k_2 N_{Af} \right\} = \int_0^\Theta d\Theta$$

$$\frac{1}{k_1 + k_2} \ln \left[\frac{(k_1 + k_2)N_{Af} - k_2 N_{Af}}{(k_1 + k_2)N_{Ae} - k_2 N_{Af}} \right] = \Theta$$

But $K = k_1/k_2$,

$$\ln \left[\frac{N_{Af}}{N_{Ae} + \frac{1}{K}(N_{Ae} - N_{Af})} \right] = k_1 \frac{(K+1)}{K} \Theta \quad \ldots \quad (65)$$

For the Forward first order—Reverse the second order.

$$A \rightleftharpoons B + C$$
$$-dN_A/d\Theta = k_1 N_A - k_2 N_B N_C$$
$$-dN_A/d\Theta = k_1 N_A - k_2 N_B N_C/V$$

Assuming N_{Bf} and $N_{Cf} = 0$,

$$-dN_A/d\Theta = k_1 N_A - k_2(N_{Af} - N_A)^2/V$$
$$-dN_A/d\Theta = \frac{k_1 V N_A - k_2 N_{Af}^2 + 2k_2 N_{Af} N_A - k_2 N_A^2}{V}$$
$$-dN_A/d\Theta = -\frac{k_2}{V}\left[N_A^2 - N_A(2N_{Af} - \frac{k_1}{k_2} V) - N_{Af}^2 \right]$$

Let $b = 2N_{Af} + \frac{k_1}{k_2} V = 2N_{Af} + KV$

Separating the variables and showing the limits for the integration,

$$\int_{N_{Af}}^{N_{Ae}} \frac{dN_A}{N_A^2 - bN_A + N_{Af}^2} = \int_0^\Theta k_2\, d\Theta/V$$

The left hand side is of the form,

$$\int \frac{dx}{ax^2 + bx + c}$$

Therefore, the integration results in,

$$\frac{1}{\sqrt{b^2 - 4N_{Af}^2}} \ln \left[\frac{2N_{Ae} - b - \sqrt{b^2 - 4N_{Af}^2}}{2N_{Ae} - b + \sqrt{b^2 - 4N_{Af}^2}} \right] \left[\frac{2N_{Af} - b + \sqrt{b^2 - 4N_{Af}^2}}{2N_{Af} - b - \sqrt{b^2 - 4N_{Af}^2}} \right] = k_2 \Theta/V \quad \ldots \quad (66)$$

For the Forward second order—Reverse second order,

$$A + B \rightleftharpoons C + D$$

where $N_{Cf} = N_{Df} = 0$

$$\frac{1}{\sqrt{b^2 - 4N_{Af}^2 a}} \ln \left[\frac{2aN_{Ae} + b - \sqrt{b^2 - 4aN_{Af}^2}}{2aN_{Af} + b - \sqrt{b^2 - 4aN_{Af}^2}} \right] \left[\frac{2aN_{Af} + b + \sqrt{b^2 - 4aN_{Af}^2}}{2aN_{Ae} + b + \sqrt{b^2 - 4aN_{Af}^2}} \right] = k_2 \Theta/V \quad \ldots \quad (67)$$

where $b = KN_{Af} - K_{Bf} - 2N_{Af}$,
$a = 1 - K$

The use of Equation 67 is shown in Example 16:

Example 16: The hydrolysis of methyl acetate is a reaction of the second order, proceeding according to the equation:

$$CH_3COOCH_3 + H_2O \rightleftharpoons CH_3COOH + CH_3OH$$

This reaction is catalyzed by the presence of hydrogen ions. In a normal solution of HCl at 25° C., the velocity constant of the forward reaction is 0.0001482 liters/(gm. mol) (min.), and that of the reverse reaction is 0.000677. The initial concentration in a given solution may be taken as $C_{Af} = 1.151$ gm. mols of methyl acetate per liter, and as $C_{Bf} = 48.76$ gm. mols of water per liter. No alcohol or acetic acid is initially present. On the basis of 1.0 liter of solution, calculate the percentage ester decomposed in 60 minutes.

Solution: Equation 67 will be modified somewhat to use concentration terms, (C's), rather than N's.

$$-dN_A/d\Theta = k_1 N_A C_B - k_2 N_C C_D$$
$$N_A = C_A/V$$
$$-dN_A/d\Theta = -V dC_A/d\Theta$$
$$-V dC_A/d\Theta = k_1 C_A C_B V - k_2 C_C C_D V$$
$$C_B = C_{Bf} - (C_{Af} - C_A) = C_A + (C_{Bf} - C_{Af})$$
$$C_C = C_D = (C_{Af} - C_A)$$

Let $C_{Bf} - C_{Af} = U$

$$-dC_A/d\Theta = k_1C_A(C_A + U) - k_2 \frac{(C_{Af} - C_A)^2}{}$$

$$-dC_A/d\Theta = k_1C_A^2 + k_1UC_A - k_2C_{Af}^2 + 2k_2C_AC_{Af} - k_2C_A^2$$

$$dC_A/d\Theta = (k_2 - k_1)C_A^2 + C_A(-k_1U - 2k_2C_{Af}) + k_2C_{Af}^2$$

Note that separation of the variables and integration will give an equation similar to Equation 67. The left hand side will contain C terms instead of N terms, and,

$$a = k_2 - k_1 = 0.000677 - 0.0001482 = 0.0005288$$

$$b = -k_1U - 2C_{Af}k_2 = -0.0001482 (48.76 - 1.151) - (2)(1.151)(0.000677) = -0.008614$$

$$c = k_2C_{Af}^2 = 0.000677(1.151)^2 = 0.0008969$$

The right hand side of the equation will be, Θ/V. This difference results from the fact that the relationship, $k_1/k_2 = K$, is not used in solving this example.

$$b^2 - 4ac = (74.20 \times 10^{-4}) - (1.897 \times 10^{-4}) = 72.30 \times 10^{-4}$$

$$\sqrt{b^2 - 4ac} = 8.505 \times 10^{-3}$$

$$\frac{-b - \sqrt{b^2 - 4ac}}{2a} = -0.017119/0.0010576 = -16.280$$

$$\frac{-b + \sqrt{b^2 - 4ac}}{2a} = 0.000109/0.0010576 = 0.1032$$

Applying the modified equation, $(\Theta/V = 60/1)$

$$60 = \frac{1}{8.505 \times 10^{-3}} \ln\left[\left(\frac{C_{Ae} - 16.280}{C_{Ae} + 0.1032}\right)\left(\frac{1.151 + 0.1032}{1.151 - 16.280}\right)\right] \ln\left[\left(\frac{C_{Ae} - 16.280}{C_{Ae} + 0.1032}\right)(-0.0828)\right] = 0.5103$$

$$\frac{C_{Ae} - 16.280}{C_{Ae} + 0.1032} = e^{0.5103}/(-0.0828) = -20.07$$

$$C_{Ae} - 16.280 = -20.07(C_{Ae} + 0.1032)$$

$$21.07\,C_{Ae} = 16.28 - 2.08$$

$C_{Ae} = 14.20/21.07 = 0.684$ gm. mols of ethyl acetate per liter

$$\% \text{ Conversion} = (1.151 - 0.684)/1.151 = 40.5$$

In other industrially important reactions, the initial reaction is followed by one or more subsequent reactions, with the primary product decomposing on reaction to form another set of products. One of the simpler cases of this type involves two first order reactions:

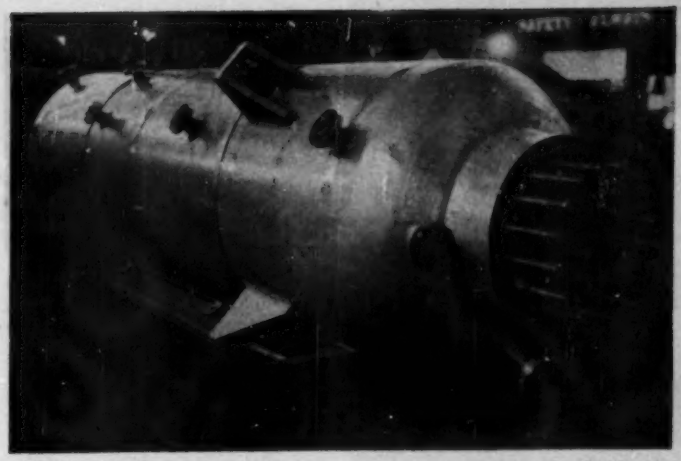
$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

$$-dN_A/d\Theta = k_1N_A$$

$$dN_C/d\Theta = k_2N_B$$

$$dN_B/d\Theta = k_1N_A - k_2N_B \quad \ldots\ (68)$$

$$\ln(N_{Af}/N_A) = k_1\Theta \quad \ldots\ (69)$$



1350-gallon Stainless Steel Lined High-Pressure Autoclave. (Courtesy of Blaw-Knox Construction Company.)

$$N_B = N_{Af} - N_A \text{ (assuming } N_{Bf} = 0)$$

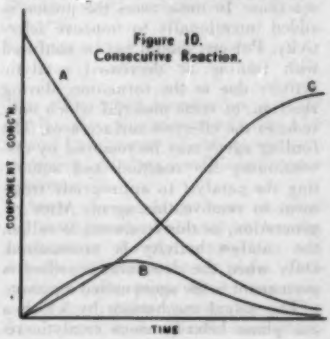
$$dN_B/d\Theta = k_1N_{Af}e^{-k_1\Theta} - k_2N_B$$

$$N_B = \frac{N_{Af}k_1}{k_2 - k_1}(e^{-k_1\Theta} - e^{-k_2\Theta}) \quad \ldots\ (70)$$

$$N_C = N_{Af} - N_A - N_B \quad \ldots\ (71)$$

If k_1 and k_2 are of about the same order of magnitude, graphical representation of the above equations will produce Figure 10. This same type of treatment may be used on the more complex orders; however, it is apparent expressions will result which are difficult to handle mathematically.

It is possible that the orignal reactants may unite in two or more different ways. In this case, those reactions occurring in addition to the desired reaction are called side reactions. Side reactions occur in a number of industrial syntheses. In a good many of these syntheses, the side reactions are of very small magnitude and may be ignored; however, in some reactions they are quite appreciable, and provision must be made to include the effects of these reactions in the final integrated rate expressions. For the simple case where both side reactions are irreversible and first order:



$$C \xleftarrow{k_2} A \xrightarrow{k_1} B$$

$$dN_B/d\Theta = k_1N_A$$

$$dN_C/d\Theta = k_2N_A$$

$$-dN_A/d\Theta = k_1N_A + k_2N_A$$

$$\ln(N_{Af}/N_{Ae}) = (k_1 + k_2)\Theta \quad \ldots\ (72)$$

For the general case,

$$C \xleftarrow{n^{th}} A \xrightarrow{m^{th}} B$$

$$dN_B/d\Theta = k_1N_A^m/(V^{m-1})$$

$$dN_C/d\Theta = k_2N_A^n/(V^{n-1})$$

$$-dN_A/d\Theta = k_1N_A^m/(V^{m-1}) + k_2N_A^n(V^{n-1}) \quad \ldots\ (73)$$

Separating the variables and integrating requires a knowledge of the numerical values for n and m. Equation 72 was derived for the case, $n = m = 1$. If both reactions are second order, $n = m = 2$, and the following differential equation results,

$$\frac{-dN_A}{N_A^2} = \frac{(k_1 + k_2)\,d\Theta}{V} \quad \ldots\ (74)$$

This equation is readily integrated for constant volume, and is only slightly more difficult for constant pressure. Since it is highly unlikely that either reaction would be of third order or higher, the only practical case remaining is for $n = 1$, $m = 2$. In this case also, it is possible to separate the variables and integrate without great difficulty.

In all processes involving simultaneous reactions, it is important to know either the complete kinetic picture, or to have experimental knowl-

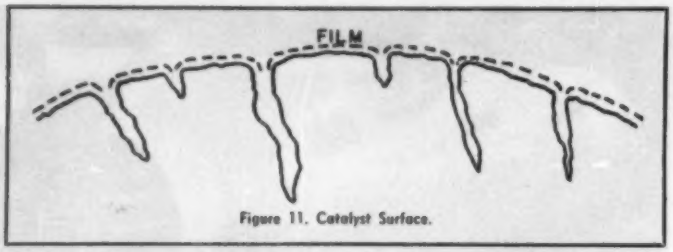


Figure 11. Catalyst Surface.

edge of types and quantities of products involved. Calculations based on insufficient data may give extremely erroneous results. Generally speaking, only one or two of these products will be of economic importance. The term, selectivity, is sometimes employed when referring to complex reactions. It is defined as the quantity of reactants going to desired products, divided by the total amount of reactants disappearing. In most cases, varying reaction temperatures and pressures, and sometimes, employing a catalyst, will increase the selectivity of a reaction.

A large number of chemical reactions carried out industrially employ catalysts. As previously mentioned a true catalyst does not influence the equilibrium yield obtainable under a given set of operating conditions. The presence of a catalyst may increase or decrease reaction rates and change the selectivity of multiple simultaneous reactions. A true catalyst is theoretically unchanged by the chemical reaction taking place. It usually is used in very small proportions, compared to the total quantity of material present.

Catalysts may be liquids, gases, or solids. Gaseous catalysts are rare, water vapor being the most common. The gas phase reaction of hydrogen and chlorine, catalyzed by water vapor, is a well known process. Liquid phase catalysts are more prevalent; acid-base, ionic, and Friedel-Craft reactions are in well known industrial use. The majority of catalysts used are solids.

Solid catalysts are of two types. Supported catalysts consist of a very thin layer of active material on an inert (or, sometimes, on a less active) carrier. Silica gel, kieselguhr, and activated alumina are good examples of carriers which have a large surface for deposition of the actual catalyst. However, these three materials are catalysts for a number of reactions as unsupported catalysts, as explained below. Unsupported catalysts consist entirely of the active material prepared in a fashion which will produce a maximum surface area. The method of preparation may consist of first producing a gel or precipitate and then drying to produce a porous structure with a large surface. The TCC (Thermofor catalytic cracking) catalyst made by Socony-Vacuum Oil Company, Inc., is produced in this manner, in the form of beads.

Catalysts are also produced by crushing the material to a fine powder, mixing with a binder, pelleting the mixture, and then removing binder (or lubricant) by mechanical or chemical means. One of the common Houdry catalysts is made by this process. Adsorption measurements indicate the surface on a well prepared catalyst is about 10^4 to 10^6 square centimeters per cubic centimeter volume.

The catalytic effect of a mixture of active materials is sometimes greater than the sum of the separate effects of the active materials. Such mixtures are termed promoted catalysts. In the synthesis of ammonia, the catalyst is iron, promoted by small amounts of potassium and aluminum oxides. The mixture of zinc and chromium oxides has proved more effective than either oxide in the formation of methyl alcohol from carbon monoxide and hydrogen.

Additions of small amounts of material to a catalyst may seriously reduce its activity. Such materials are called catalyst poisons. Sulfides were notorious for this effect on the earlier catalysts used in the catalytic cracking of petroleum. Occasionally a poison is encountered which will poison a catalyst for only one of two possible reactions. In these cases the poison is added intentionally to improve selectivity. Poisons should not be confused with fouling or decreased catalytic activity due to the formation, during reaction, of some material which only reduces the effective surface area. The fouling agent may be removed by discontinuing the reaction and submitting the catalyst to appropriate treatment to remove this agent. After regeneration, as this treatment is called, the catalyst activity is unimpaired. Only when the deterioration effect is permanent is the agent called a poison.

The actual mechanism by which a gas phase heterogeneous catalytic reaction takes place may be easily visualized by means of Figure 11. In order for a molecule of the compound to react on the surface of the catalyst, the molecule must proceed through nine steps:

1) It must move by convection from the main body of the gas to the surface of the gas film (indicated in Figure 11).
2) It must move by molecular diffusion to the exterior surface of the catalyst.
3) It must next be transferred to the surface within the pores. (Experimental evidence has shown that the major portion of surface area of a catalyst is on the pore walls.)
4) It must then be adsorbed by the actual surface.
5) Reaction takes place.
6) The products are desorbed.
7) Products diffuse to the exterior surface of the catalyst.
8) The products undergo molecular diffusion through the gas film.
9) The products then proceed by convection to the main body of the gas.

Theoretically, each one of these steps represents a resistance to reaction and requires a definite driving force to overcome this resistance. In actual practice the magnitude of one, two, or as many as eight of these resistances may be negligible. This occurrence must be determined experimentally unless very complete and extensive data are available. Methods of estimating the magnitude of resistance of each film when these data are available will be presented.

The problem of material transfer through the main body of the gas to the gas film interface has been described as convection or eddy diffusion. Data which would enable predictions of the rates are very meager, practically non-existent. The only redeeming feature is the fact that the resistance encountered in this transfer is almost always negligible.

The transfer mechanism through the gas film is known to be molecular diffusion and has been investigated quite thoroughly by Maxwell[1] and Stefan[2]. The final form of the equation for gaseous diffusion under steady state conditions in binary mixtures, both components diffusing in opposite directions is:

$$-dp_A/dz = (\pi/D_m)\,(dN_A/dA) \quad \ldots (75)$$

This equation may be integrated for a given film thickness (B_f) and known partial pressures on both sides of the film (p_{ag} and p_{ai}),

$$dN_A/dA = (D_m/\pi)\,(p_{ag} - p_{ai})/B_f \quad \ldots (76)$$

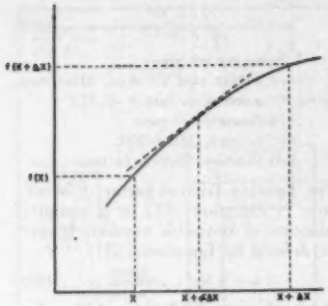


Figure 12. Law of the Mean.

z = film thickness
D_m = diffusivity coefficient
A = cross sectional area of diffusion

The diffusivity coefficient is this equation may be predicted by means of an equation developed by Gilliland[2],

$$D_m = \frac{0.0043\ T^{(3/2)}\sqrt{1/M_A - 1/M_B}}{(V_A^{(1/3)} + V_B^{(1/3)})^2\ \pi} \quad (77)$$

V_A, V_B = atomic volumes of A & B[4]
M_A, M_B = molecular weight, A & B

Values for the film thickness are not predictable in most cases, but may be estimated if experimental data on film diffusion are available. The value of the partial pressure at the surface of the catalyst is usually unknown but

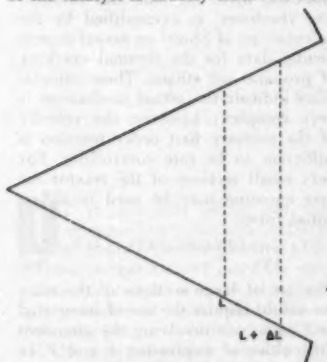


Figure 13. Catalyst Pore.

may be found by trial and error calculations in conjunction with equations to be presented later.

After the reactants have been transferred through the surface film, it has been assumed[3] that they are transferred to the actual interior pore surface of the catalyst by a diffusional process in accordance with Fick's Law. Thiele treats various cases, including various shapes of catalysts, orders of reaction, and isometric and non-isometric conditions. The essential features of all these cases are shown by the equation developed for an isometric first order reaction on spherical catalysts:

$$\frac{dN_A}{d\Theta} = \frac{DAC_A}{R}\left[\frac{hR}{\tan h\ (hR)} - 1\right] \quad (78)$$

L = distance from center of catalyst pellet (Used in Equations 79 and 80)
D = diffusion coefficient
C_A = concentration of reactant
A = area of pore cross section
R = radius of catalyst pellet
r = hydraulic radius of the pore
$h = (c/Dr)^{1/2}$
c = rate of reaction, (mols)/(time) (surface area)

It is interesting to note how easily a problem of this type may be set up using the Law of the Mean. Unfortunately, most engineers are not acquainted with this fundamental mathematical relationship. It operates exactly on any problem involving mass or energy transfer and allows a theoretically correct solution using finite increments rather than the misused "infinitesimal increments". The Law of the Mean simply states that the incremental change in a function of x may be calculated by the product of the change in x and an average value of the slope at some point intermediate between x and $x + \Delta x$. (See Figure 12.) This point is termed $x + \alpha\,\Delta x$. The problem in question may be mathematically established by considering a pore in the spherical catalyst (Figure 13). A material balance over the cross sectional volume of the pore yields:

Material In — Material Out = Material Reacted

Applying Fick's Law,

$$DA\left.\frac{dC_A}{dL}\right|_L - DA\left.\frac{dC_A}{dL}\right|_{L+\Delta L} = c\,\bar{C}_A\,\bar{A}\,(-L)/r \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (79)$$

Applying the Law of the Mean to Equation 79,

$$\Delta L\left(DA\ d^2C_A/dL^2\Big|_{L+\alpha\Delta L} - D(dA/dL)(dC_A/dL)\Big|_{L+\alpha\Delta L}\right) = -c\bar{C}_A\bar{A}\,\Delta L/r$$

Dividing by ΔL and taking the limit as $\Delta L \to 0$,

$$DA(d^2C_A/dL^2) + D[(dA/dL)(dC_A/dL)] = -c\,C_A\,A/r \quad \ldots\ldots\ldots\ldots\ldots\ldots (80)$$

This differential equation is a form of Bessel's Equation and may be solved by the use of tables and appropriate boundary conditions to yield Equation 78.

After the reactants have reached the surface of the catalyst by the mechanism shown, adsorption and subsequent reaction take place. Two types of adsorption have been proposed by various investigators. The first type, Van der Waal's adsorption,

Reaction Kettle with Steam Jacket and Spiral Agitator. (Courtesy of Blaw-Knox Construction Company.)

has been described as caused by forces very similar to those causing condensation. As the molecules approach the surface, the intermolecular forces existant between like and unlike molecules increase until their magnitude is greater than the kinetic energies of the moving molecules, and adsorption takes place. It is thought that Van der Waal's adsorption may produce several layers of molecules at the catalyst surface.

The second type of adsorption known is activated or chemisorption. Langmuir has suggested that this type of adsorption is caused by forces similar to those concerned in chemical bonds. Because of the nature of the catalyst surface, certain surface atoms or molecules will project from the surface at the edges or corners. These atoms will not have their electrostatic forces neutralized by attracting adjacent surface atoms, but will project a field above the catalyst surface. Atoms which act in this manner are called unsaturated atoms and constitute the active centers involved in catalysts. The distance between active centers will influence properties of the material as an adsorbent and catalyst. Depending on the specific catalyst and reactants involved, there are many possible surface reactions that may take place. If the reaction is unimolec-

ular the decrease in activation energy caused by the surface adsorption may increase the reaction velocity. The molecule may be adsorbed by adjacent (dual site) active centers and consequently be dissociated. Unlike molecules may be adsorbed by dual sites and react. In other instances an activated complex may be formed which later dissociates to produce the end products.

The theory of chemisorption reactions has been well developed by the various investigators to a point where quite accurate predictions may be made about the performance of catalytic convertors. Unfortunately, these equations require knowledge which the average process engineer does not have at his disposal. At some later date, these data may be generally available for use, as a result of pure scientific research. An equation has been listed below to indicate the problems involved. This equation indicates the rate of reaction for a reversible first order reaction controlled by the catalyst surface: $A \rightleftharpoons R$,

$$r = \frac{E_A C T e^{-(\Delta H^\circ/RT)}}{(1 + a_I K_A + a_R K_R + a_I K_I \cdots)^n \{a_I K_A - (a_R K_R/K')\}} \quad \ldots\ldots (81)$$

r = reaction rate, [mols/(vol) (time)]

K_I, K_A, K_R = adsorption equilibrium constants for I, A, & R, on the catalyst. I refers to inerts.

K' = chemical equilibrium constant for reaction on the catalyst surface

a_I, a_A, a_R = activities of I, A, & R

E_A, C = constants to be evaluated.

The various constants involved in this equation may be evaluated with sufficient experimental data. The adsorption equilibrium constants are determined by making a series of runs (usually three) at varying activities of the component in question, holding the activities of the other components constant. These runs must then be repeated at a new temperature to permit calculation of the variation of the adsorption equilibrium constants with temperature. Once all equilibrium constants are evaluated each single rate measurement permits calculation of the group,

$$C e^{-\Delta H^\circ/RT}.$$

Additional information concerning Equation 81 may be found in an article by Hougen and Watson.[6]

As previously noted, the engineer confronted with a problem in reactor design should collect enough data to indicate the resistance controlling the reaction. In many cases it will be found that mass transfer, rather than surface reaction is important. Hurt[7] lists the comparative importance of time required for mass transfer and the time required for surface reaction, for the four reactions shown in Table A.

TABLE A

REACTION	Percent of Total Reaction Time	
	Mass Transfer	Surface Reaction
$CO + H_2O \longrightarrow H_2 + CO_2$	60	40
$CO + 3H_2 \longrightarrow CH_4 + H_2O$	50	50
$2CH_3OH + O_2 \longrightarrow 2HCHO + 2H_2O$	80	20
$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$	100*	..

* Chain Reaction.

Discussion of the calculation of the kinetics of non-isothermal reactions has been postponed to this point in spite of its relative industrial importance, because its treatment is dependent on the principles and fundamentals examined in the previous discussion.

The usual problem confronting an engineer dealing in kinetics concerns a reaction taking place under varying temperature and pressure conditions. The solution to a problem of this type is intrinsically one of the trial and error type, with both temperature and pressure profiles to be established for the reaction under consideration. One method of handling these calculations is to divide the reactor into small segments. In these small sections, the variations of three interrelated items must be determined. These items are pressure drop, temperature change, and conversion. The most direct method of attack involves a temperature change and a pressure drop in the first arbitrary section. With a known average temperature, the values of the reaction velocity constants may be found. These data may then be used to calculate the conversion in the section. An energy balance for the section using appropriate heats of reaction will enable the assumed temperature to be checked. After the temperatures have been adjusted, a pressure drop calculation is made to check the original assumption. This procedure is repeated until all assumed values agree with the calculated values. The remaining sections are then calculated until the desired conversion level is reached. At this point the overall reactor pressure drop is examined. If the value is not within the limitations of pumps and equipment, the entire trial and error process is repeated, starting with a new value of the initial pressure.

The pressure drop encountered in any specific reactor section may be calculated by means of the Fanning or Darcy equation for steady flow of fluids in circular pipes running full of fluid under isothermal conditions:

$$F = \frac{32 f L W^2}{\pi^2 \rho^2 g_c D^5} \quad \ldots\ldots (82)$$

L = length of pipe
W = weight rate of flow, Mass/time
g_c = conversion factor = 32.2
D = diameter of pipe
ρ = density, Mass/Vol.
f = Fanning friction factor.

The Fanning friction factor, *f*, occurring in Equation (82) is a complex function of Reynolds number. It may be defined by Equation (83):

$$f = a + b\,Re^c \quad \ldots\ldots (83)$$

Re is the standard abbreviation for Reynolds number. The values of the specific constants in Equation (83) depend on the flow condition, whether streamline or turbulent. An alignment chart[8] has been constructed based on turbulent flow in clean steel pipe. For these conditions,

$$f = 0.04\,Re^{-0.16}$$

In order to achieve the maximum utility from this chart a graph indicating the viscosity of the reaction mixture versus temperature at different conversion parameters should be constructed.

Fortunately, the calculation of conversion for the majority of industrial processes may sometimes be easily made by assuming the reaction mechanism is first order. This assumption may be made for extremely complex reactions involving side and consecutive reactions, as exemplified by the calculations of Shutt[9] on actual experimental data for the thermal cracking of propane and ethane. These calculations indicate the actual mechanism is very complex; however, the velocity of the primary first order reaction is sufficient to be rate controlling. For very small sections of the reactor the rate equation may be used in differential form:

$$\Delta N_A = -(dN_A/dV_R)\Delta V_R = k(N_A/V)\Delta V_R \quad \ldots\ldots (84)$$

The use of large sections of the reactor would require the use of integrated rate equations involving the attendent difficulties of expressing *k* and *V* in terms of N_A or V_R. Generally speaking it is usually easier to work with small sections where arithmetic averages closely approximate the true effective values.

End of Part III and series.

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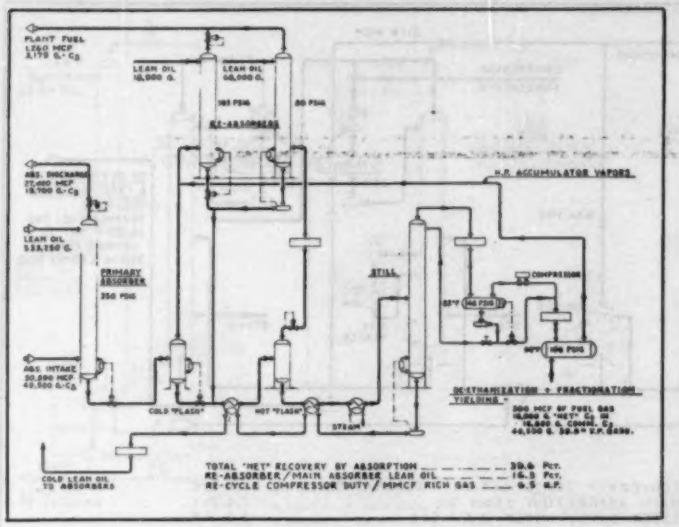

Figure 1. Single-Stage Rich-Oil Distillation with Plant-Vapor Re-Cycle.

LOOKING TO an expanded market for propane, natural gasoline plants will undergo changes in processing schemes to meet the new market demand. Compared with the conventional process schemes, the use of rich-oil rectification offers the advantage of high-percentage absorption recovery of propane with less heat consumption. With this scheme it will usually be necessary to employ an auxiliary trimming control for correlating the unit's operation with 24-hour cyclic changes in plant-intake quality. Of the various auxiliary controls available, direct measurement and control of the volume of vapors introduced into the base of the rectifier offers the most promise.

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RICH OIL RECTIFICATION

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IT IS generally recognized that propane bears the same relation to today's natural gasoline plant operations that natural gas bore only a few years ago—namely, that it is only a matter of time until sufficient transportation and storage facilities will be made available whereby this lightest of liquefiable petroleum fuels will be conserved and marketed "as such" to the full capacity of the majority of its more efficient production facilities. Consequently, most of today's natural gasoline plants contemplating a reasonably extended operating life can anticipate a near future, if not immediate, serious questioning regarding their ability to efficiently produce high-percentage yields of propane.

A properly processed rich-oil rectifying unit is an essential element in such production; and on this basis we will discuss the prime function of the rich-oil rectifier, when its employment should be seriously considered, some important economic and operational comparisons of various rectifier flow arrangements, and several important efficiency and specialized control factors associated with the rich-oil rectifier operation.

The essential role played by the rich-oil rectifier in modern high-recovery propane operations can be best appreciated by an understanding of its development background through several extensively employed earlier process cycles—hence the first part of this paper will be devoted to a brief review of that phase of the subject.

In early absorption plant operations propane recovery was a "side issue," and equipment design focused almost solely on effecting desired recoveries of butane and heavier fractions from the rich gas. Under these circumstances oil-circulation rates were quite low, and even though the stripping stills were operated at relatively low pressures, the resultant volumes of light vapors released from the rich-oil "flash tanks" and stripping-still "accumulators" were correspondingly low—with the result that such vapors could be and were readily handled at appropriate reabsorbers at little additional investment and operating cost.

As the early low oil-circulation rates were increased looking to increased propane recoveries, however, the accompanying volumes of plant vapors requiring reabsorption treatment steadily increased, with this increase being particularly marked in the case of the still-accumulator vapors. Eventually these recycled vapor volumes became sufficiently large, and the costs of their handling sufficiently important, to call for process changes in the original simple low-pressure plant cycles.

The most obvious initial cycle change, and one which was readily applicable to existing low-pressure plants, involved compressing the low-pressure still accumulator vapors to a substantially higher pressure for introduction into a second, high-pressure, condensing and accumulating stage—with the low-pressure still condensate being simultaneously pumped into the higher pressured condenser for its "sponge" effect. This change improved the efficiency of the increased propane recovery operations by both decreasing the volume of accumulator vapors released, and increasing the pressure at which their reabsorber could be operated. This initial improvement,

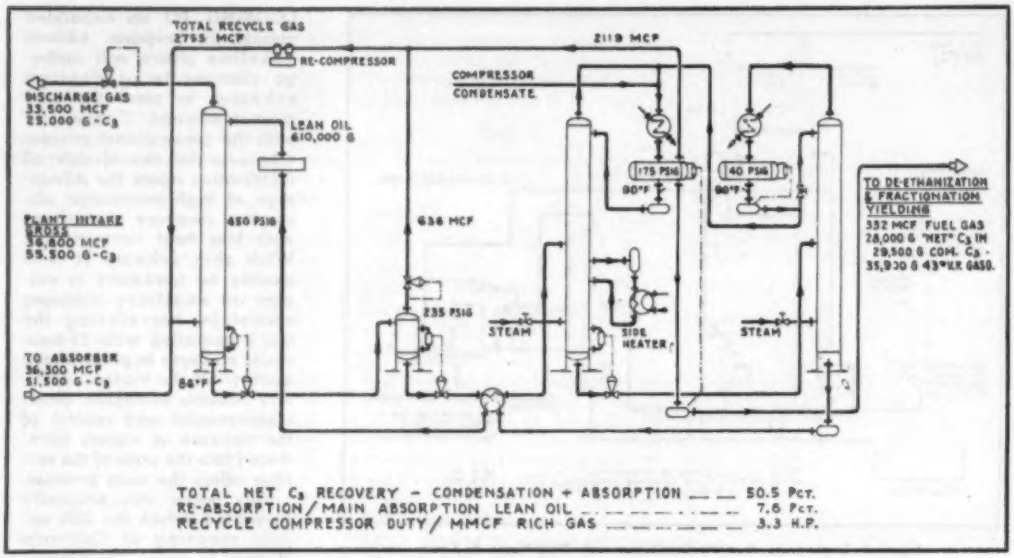


Figure 2. Two-Stage Rich-Oil Distillation with Plant-Vapor Recycle.

however, proved to be economically effective over only a small additional propane recovery range.

Figure 1 presents typical key operating data for such a cycle operating at the upper edge of economic applicability on a 350-psig rich oil. Although the absorber recovery of propane in this particular instance amounted to only 51.4 percent (with a corresponding net stock-tank recovery of only 39.6 percent), both reabsorption-oil rate and recompressor horsepower requirements were such as to obviously preclude economic increasing of the noted relatively low propane recoveries. The reason for the relatively poor economic showing of this particular cycle resides in:

1) The large volume of vapors handled by the recompressors at relatively high compression ratios—resulting in the employment of 6.5 horsepower per million cubic feet of rich-gas feed for the example of Figure 1.

2) The low pressures employed at the reabsorbers—resulting in a reabsorption oil requirement of 16.3 percent that of the main-absorber oil circulation for the example of Figure 1.

Two-Stage Stripping Still Cycle

The next, and quite generally adapted, process solution for the above-noted weaknesses of the "low-pressure still, vapor recompressor" cycle was the two-stage stripping still cycle in which the first stage of vapor compression was effected by application of heat, rather than mechanical, energy. In this cycle the rich oil is initially stripped of its lightest fractions at a still operating in the same general pressure region as the recompressor discharge of the previously-discussed cycle, after which the remaining heavier components of the rich oil are recovered at a second, substantially lower-pressured still operating "total condensing." As with the previous cycle, the second stage condensate is pumped over the first stage high-pressure condenser for its sponge effect, and the vapors discarded from the high-pressure accumulator are treated at an appropriate reabsorber—with these vapors often being recompressed to main absorber pressure for high-pressure absorption at the main absorber along with the rich plant-intake gas.

Figure 2 presents typical key operating data on such a two-stage stripping still unit handling rich-oil from a 450-psig absorber. While the operation of this particular unit cannot be compared in detail with that of Figure 1 due to differences in feed quality and absorber pressures, as well as the fact that compressor condensate was being handled in the Figure 2 operation while omitted from Figure 1, it nevertheless is clearly evident that the cycle of Figure 2 is a distinct improvement over that of Figure 1 in that:

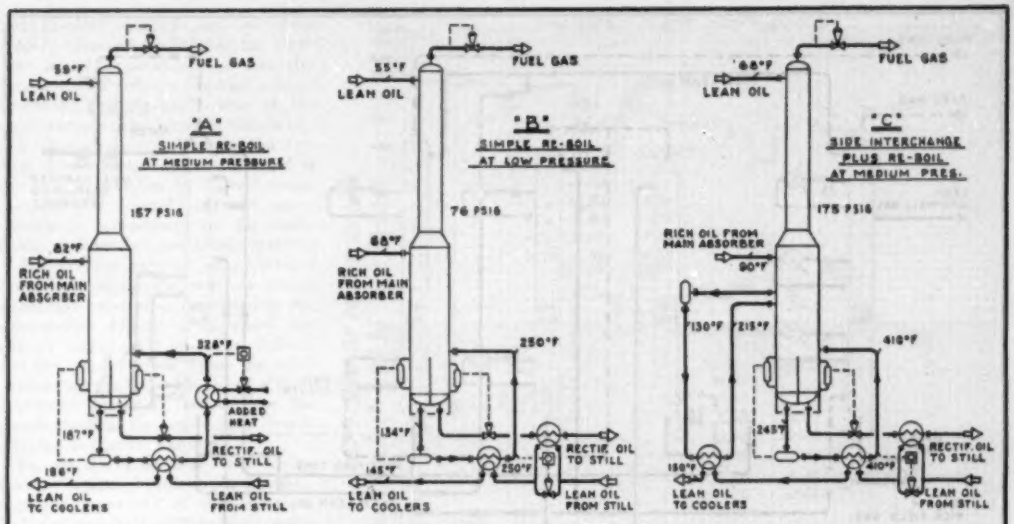
While the main-absorber propane recoveries were of the same order for both cycle examples, only half as much recompressor horsepower, and less than half as much reabsorber lean-oil, was required by the two-stage still cycle to equal (if not exceed) the stock-tank recovery of absorbed propane obtained with the single-stage still cycle.

While relatively efficient in the 50 percent propane recovery region, the two-stage stripping still cycle falls off rapidly in recycle-vapor handling efficiency at propane recoveries above this figure due to "compounding" of the accumulator recycle-vapor volumes at the higher propane recovery rates. This "compounding" results from the following basic absorption relationships:

1) By the time propane recoveries of the order of 50 percent have been achieved, all available heavier ends have been recovered and already employed for their "sponge" effect in holding the earlier recovered propane in the still-accumulator liquid—hence any additional propane recovery must "stand on its own feet" in effecting the liquid-composition adjustments required to add it "as a liquid" to the earlier recovered liquid products.

2) Process designers have in general found it necessary to limit the second stage condenser pressures to levels only slightly higher than the vapor pressure of pure propane at available condenser temperature. Hence, if the "50 percent plus" increment of propane reaching the accumulator carries any appreciable amount of ethane and lighter fractions with it, the only way said propane increment can get into the accumulator liquid is to "pump" lighter undesired fractions therefrom by development of a large propane recycle between the reabsorber and still accumulator—which action accounts for the noted "compounding" of recycle-vapor volumes with the conventional two-stage stripping still cycle at propane recoveries above 50 percent.

The obvious answer to this last process problem resides, of course, in the distillation removal of all unde-



PROCESS-FLOW COMPARISONS

		A	B	C
MAIN ABSORBER PRESSURE	PSIG	553	360	450
MAIN ABSORBER OIL RATE	GAL L.O./M.C.F. R.G.	11.2	28.4	15.6
MAIN ABSORBER RECOVERY OF PROPANE	PCT.	59.3	88.1	65.0
RICH-OIL RECTIFIER RETENTION OF PROPANE	PCT.	91.6	96.4	88.0
"NET" OVERALL PROPANE RECOVERY	PCT.	54.3	85.0	57.0
RE-ABSORBER / MAIN-ABSORBER LEAN OIL	PCT.	21.4	49.2	12.5
"R.O. FROM ABS.-L.O. TO COOLER" APPROACH	°F	114	77	60

Figure 3. Interchanger Arrangements for Rich-Oil Rectification.

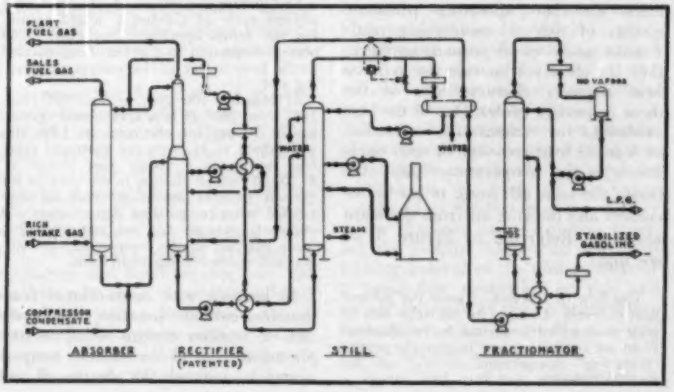
sired light fractions from the rich-oil stream ahead of the stripping still. When the undesired lights are thus removed, all absorption-recoverable propane can be readily retained in the still overhead product at conventionally prevailing accumulator pressures and temperatures. Furthermore, the still condenser can then be operated "totally condensing" with employment of only a single distillation stage.

Broadly, such rich-oil distillation units may be called upon to sharply cut a portion of the absorption-recovered propane to fuel gas for production of a close-specification vapor-pressure LPG; to sharply cut between ethane and propane for maximum production of close-specification vapor-pressure commercial propane; or to sharply cut a portion only of the ethane overhead looking to production of a finished light-liquid stream containing a relatively high-specification quantity of ethane.

This range of rich-oil distillation requirements can be fully met by replacing the conventional rich-oil "flash tanks" with a tray-equipped rectifying column, feeding the resultant rectifier overhead stream into an appropriate reabsorption column, and returning the resultant rich reabsorption oil to the rectifier—which equipment arrangement constitutes the "rich-oil rectifier" of the subject paper.

The earliest rich-oil rectifier designs drew on conventional distillation practice for their formulation—resulting in simple reboil-heated units such as described by Whistler.[1] While these earlier units employed hot lean oil for their major heat supply, the temperature levels of their operation were such that large amounts of low-level heat had to be discarded from the lean oil at the lean-oil water coolers when operating at the higher, more efficient, reabsorber pressures. Operating at lower reabsorber pressures to conserve this low-level heat, on the other hand, required employment of undesirably high reabsorption oil circulation rates. Later, the rectifier "side stream" heat-interchange cycle[2,3] was developed as a solution to the uneconomic alternates of these two earlier simple reboil cycles.

Figure 4. Production of Specification LPG with Varying Quality Intake by Direct Adjustment of Rectifying Vapor Rate-of-Flow.



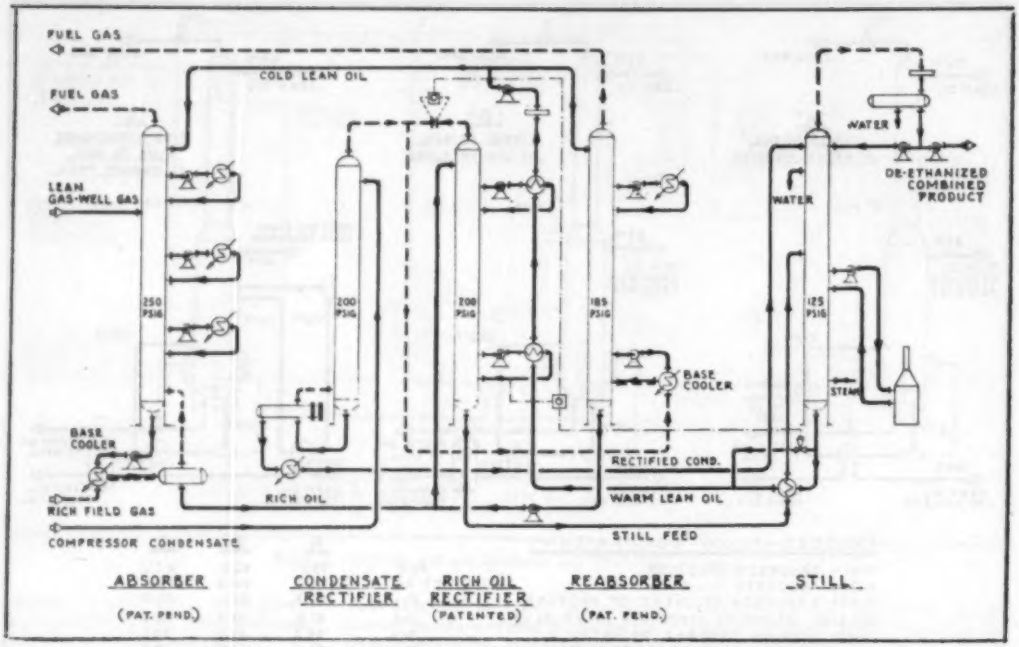


Figure 5. Production of Specification Propane with Varying Quality Intake by Combination Adjustment of Reboil Temperature and Vapor Flow.

Comparative Process Data

Figure 3 presents comparative key process data for these three rich-oil rectifier cycles. In this figure, Column *A* presents data on a conventional base-heated rectifier operating in the upper range of normally employed reabsorption pressures; Column *B* presents data on a similar conventional unit operating at a low reabsorber pressure; and Column *C* presents data on a typical "side-stream" heat interchanged unit operating in the upper reabsorber pressure range.

While these particular operations cannot be directly compared "down to the last detail" due to variations in main absorber operating pressure, quality of rich oil undergoing rectification, and over-all propane recovery, they do clearly illustrate the relative heat recovery characteristics of the three respective cycles. One of the best yardsticks for comparative evaluation of lean-oil heat recovery in such operations is the temperature "gap" between the lean oil going to the water coolers and the rich oil from the main absorber. Referring to Figure 3 we see that:

The flow of Column *A* gave the poorest heat recovery. In fact, its recovery was so poor that added heat had to be obtained from an outside source to provide proper "trimming" temperature control on the rectifier reboiler.

The flow of Column *B* so improved on the heat recovery accomplished with Column *A* that additional heat could be recovered from the lean oil by appropriate heat interchange with the rectified rich-oil on its way to the still. However, the low reabsorption pressure which made this heat recovery possible called for a corresponding undesirably large reabsorber oil ratio.

The flow of Column *C*, while operating with the highest heat recovery of the three cycles, simultaneously operated at the highest reabsorber pressure and lowest reabsorber oil rate.

Appreciation of the economic significance of the heat-recovery differences exhibited by these three different cycles may be enhanced by noting that:

1) Operating Column *A* on the more efficient cycle of Column *C* would permit, for the actual operating case cited, a 40 percent reduction in the heat load carried at the fired heater of the companion stripping still.

2) Heating 100 gpm of lean oil from 150° F. to 200° F. in a fired heater operating at 70 percent efficiency on 1200 Btu gas valued at 15 cents per thousand cubic feet represents a yearly fuel charge of $1,700.00—which charge, in the case of the rich-oil rectifier operation, must be augmented by corresponding depreciation and operating charges for the additional Btu loads imposed on the companion still-heating and water-cooling equipment.

In keeping with conventional fractionating-column practice, the early rich-oil rectifier designs relied on simple adjustment of the reboiler temperatures to control the degree of cut between overhead-rejected light fractions and absorption-oil retained heavier components. When applied to the daily cyclic change in plant-intake quality encountered in most absorption plants, however, this simple control often proved inadequate—particularly for plants operating in the upper propane-recovery ranges. As a consequence, various secondary "trimming" controls have been added to the primary reboiler-temperature control for effecting those precise secondary adjustments required to keep the rectifier operation in step with daily cyclic changes in plant-intake quality. Of such controls, the following are currently employed in one or more plants with which we are familiar:

1) Recycling of uncondensed vapors from the stripping-still accumulator back to the rectifier reabsorber.

2) Recycling of a stream of depropanized liquid from a product fractionator back to the rectifier.

3) Adjusting of the main absorber lean-oil rate to hold a constant propane or isobutane absorption factor at the main absorber.

4) Adjusting the pressure carried on the rich-oil rectifier.

5) Adjusting the lean-oil rate to the rectifier reabsorber.

6) Adjusting the rate of rectifying-vapor flow into the rectifier base.

If the variation in plant intake quality is not extreme, our experience indicates that precise control of final

light-product quality can be most readily obtained by holding the rectifier reboil-temperature substantially constant with either a fixed oil rate or constant "lean-oil/gas" ratio at the main absorber and rectifier reabsorber, and appropriately adjusting the volume of rectifying vapors employed at the rich-oil rectifier by "direct measurement and control" of said vapor volume to compensate for the daily cyclic changes in plant-intake quality.

An excellent example of a rectifier operation employing such a direct vapor-flow control is presented in accompanying Figure 4, in which the vapors introduced into the rich-oil rectifier are obtained from the still-product accumulator by aid of a flow-controller operating to regulate the temperature of the production stream entering the accumulator.

In one operation with this equipment, a maximum amount of butanes-plus are recovered at the absorber, and the resultant still-product separated at the single fractionator into a 15.0-15.5 pound stabilized gasoline bottoms and a 100 or 125 pound LPG overhead. The amount of absorption oil employed with this operation to achieve maximum recovery of butanes at the main absorber is such that the amount of propane simultaneously recovered is more than can be blended into specification LPG with the butanes remaining from the production of 15.0-15.5-pound gasoline. As a consequence, a portion of the absorbed propane has to be discarded overhead at the rich-oil rectifier, and employment of the indicated "measured" rectifying-vapor volume control makes it possible to so precisely adjust the quantity of propane thus discarded that an extremely close control can be maintained on the vapor-pressure of the resultant LPG product. In fact, with this particular control, the plant in question finds no difficulty whatever in regularly holding its LPG shipments within plus or minus 1.5-2.0 pounds of their specification mean.

In Table 1 are presented pertinent operating data from this unit which clearly demonstrate why control by adjustment of the rectifying-vapor flow, rather than conventional adjustment of the reboiler temperature, makes possible an extremely close control on the resultant LPG vapor pressure. Referring to this table, it will be noted that with most pertinent operating conditions remaining substantially constant, a seven-pound variation in the LPG vapor pressure resulted in only a 3° F. temperature difference in the rich-oil leaving the rectifier base—which small temperature difference is obviously outside the range of practical intermediate adjustment. On the other hand, the volume of rectifying vapors introduced into the column base changed from 1700 to 1425 thousand cubic feet per day—which variation is large enough to permit of precise intermediate adjustment for production of a range of vapor pressures between the 118 and 125-pound figures of the table.

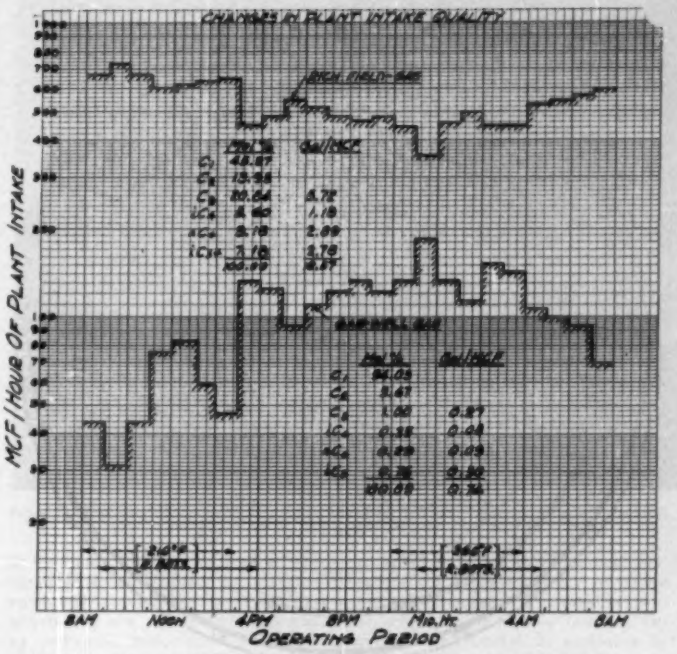


Figure 6. Rectifier Bottoms Temperatures vs. Changes in Plant Intake Quality.

While simple adjustment of an appropriate secondary control with the rectifier base-temperature held substantially constant will suffice to yield close control of light-end product quality when the cyclic changes in plant-feed quality are not too large, cases where such changes are extreme often require a coordinated adjustment of the rectifier bottom temperature with the secondary control adjustment.

A simplified flow-sheet of a plant installation employing such a dual control is presented in Figure 5. This plant handles two streams of intake-gas of widely different composition, namely, streams having concentrations of propane and heavier of some 12.50 and 0.75 gallons per thousand cubic feet. A specially cooled absorber is employed for handling the two gas streams, with the rich-gas stream being introduced into a base-cooler associated with the bottom section of the column while the lean-gas stream is introduced near the top of the column. Oil circulation rates are maintained at a constant "lean oil/lean gas" ratio with an appropriate ratio controller.

Figure 6 presents a characteristic 24-hour plant-intake record for this unit from which it will be seen that the rich-gas intake rate may vary more than twofold, and the lean-gas intake rate more than sixfold, over a 24-hour period. By appropriate interlocking of temperature and vapor-flow controls at the rich-oil rectifier while holding a constant "lean oil/lean gas" ratio at the reabsorber, it is possible to automatically compensate for the extreme range of plant-intake quality represented by the flow volumes of Figure 6 while consistently producing extra-high yields of close-specification quality propane (i.e. 95 percent propane absorption followed by a 95 percent rectifier retention of propane containing not over 4 percent ethane).

Due to the mechanical arrangement of the equipment in question, it was found more convenient to control the rectifier on the basis of the vapor volumes leaving the top of the rectifier rather than the vapor volumes entering the rectifier base—and the interlocking control of the unit consists of a vapor-flow controller on this exit stream arranged to reset a temperature controller adjusting the heat supply to the rectifier reboiler.

From "cut and try" experience, it

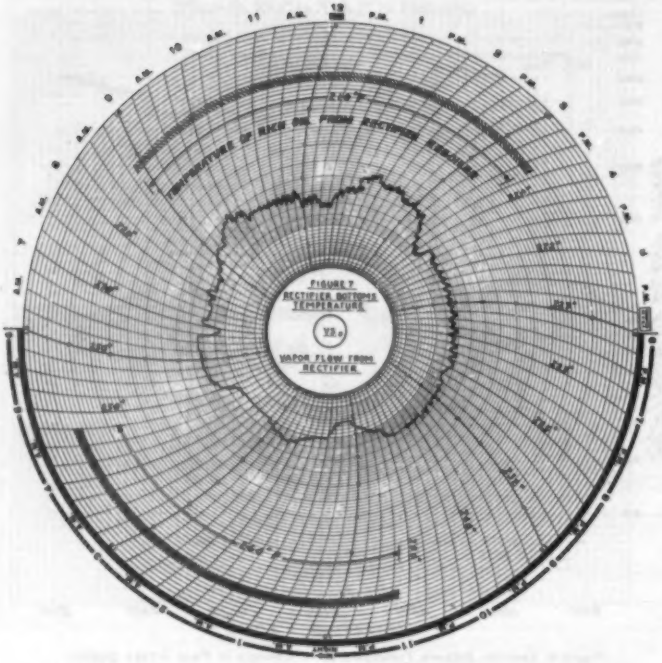


Figure 7. Rectifier Bottoms Temperature vs. Vapor Flow from Rectifier.

has been determined that for intermediate mixtures of plant-intake streams in the volumes normally encountered, maintenance of a vapor-flow from the rectifier in the amount of 4.5 to 5.0 units on the flow-controller chart will produce a finished propane product containing not over 4.00 percent of ethane. By similar experience, it has also been determined that the rectifier bottoms cannot be allowed to drop below 210° F., and need not be heated above 260° F., for maintenance of this ethane specification irrespective of the resultant volume-flow of vapors from the rectifier. On the basis of these experimentally-derived control factors, therefore, the interlocking "vapor-flow, bottoms-temperature" controls are adjusted so that the vapor-controller will reset the temperature-controller to maintain a vapor flow between 4.5 and 5.0 units on the flow chart between temperature limits of 210° F. and 260° F.—while corresponding "blocks" are set on the temperature-controller whereby this unit will thereafter maintain said temperature limits irrespective of the volumes of vapor-flow developed.

Figure 7 presents a 24-hour chart record of the vapor-flow from this unit, together with an hourly record of the temperature maintained at the rectifier base, for the same operating period as Figure 6. Referring to Figure 7, it will be seen that from 8:50 a.m. until 3:40 p.m. the equipment operated at a fixed-temperature control of 210° F. on the rectifier base; then in keeping with changing plant intake quality, the control temperature was gradually raised from 210° F. to 260° F. between 3:40 p.m. and 11:10 p.m. From 11:10 p.m. to 4:45 a.m. the equipment operated at a new fixed-temperature control of 260° F.; thereafter, due to again changing intake quality, the temperature was gradually dropped from 260° F. to 210° F. by 8:50 the following morning.

In keeping with these temperature shifts, it will be noted that during the periods of changing temperature the rate of rectifier vapor-flow was held largely between 4.5 and 5.0 units, while during the 210° F. operation it rose to a maximum of 6.3 units, and during the 260° F. operation it fell to a minimum of 3.2 units.

For interest in correlating the plant feed composition with these changes in rectifier temperature control, we have indicated the periods of fixed rectifier temperature by appropriate solid lines on the bottom of Figure 6. It should be noted that these solid lines are offset with parallel dashed lined by approximately one hour; that the dashed lines clearly define periods of maximum and minimum rich-gas intake; and that their one-hour "offset" from the solid lines represents the time lag of the rich-oil flow through the large rich-oil surge drum employed to smooth out the plant's operation.

This particular operation is the most dramatic we have encountered to date in demonstrating the limitation of the simple base-temperature control for precise adjustment of a rich-oil rectifier operating on a high-recovery propane cycle—which limitation possibly accounts for considerable of the troubles encountered in the past with certain of these units in the field.

Summary

The position of the rich-oil rectifier in plants anticipating a high-percentage absorption recovery of propane may be summarized as follows:

1) The prime function of the rich-oil rectifier is to efficiently remove all undesired light components from the rich-oil ahead of the stripping still with a minimum accompanying loss of desired heavier fractions.

2) Installation of a rich-oil rectifier should be given serious consideration whenever stock-tank recoveries of "net" propane are desired in excess of 50 percent.

3) The excessive heat consumption of the earlier simple cycles can be substantially reduced by employment of appropriate "side-stream" heat interchange at the rectifying section of the unit.

4) In high-percentage propane recovery operations, it will usually be necessary to employ an auxiliary "trimming" control in addition to the conventional base-temperature control for correlating the unit's operation with 24-hour cycle changes in plant-intake quality.

5) Of the various auxiliary controls available, direct measurement and control of the volume of vapors introduced into the base of the rectifier offers the most promise—particularly when correlation with an adjusted bottoms temperature control is required.

6) If the 24-hour cyclic change in feed quality is large, it will usually be necessary to coordinate adjustment of both the reboil temperature and the auxiliary control to obtain the desired objective of high rectifier-retention of desired fractions with precise control of light end-product quality.

ACKNOWLEDGMENT

We wish to express our indebtedness to the many individuals who have assisted us with time, material and advice in collecting the process data upon which this paper is based, and to their companies for making such data available.

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Petroleum's Part in European Recovery

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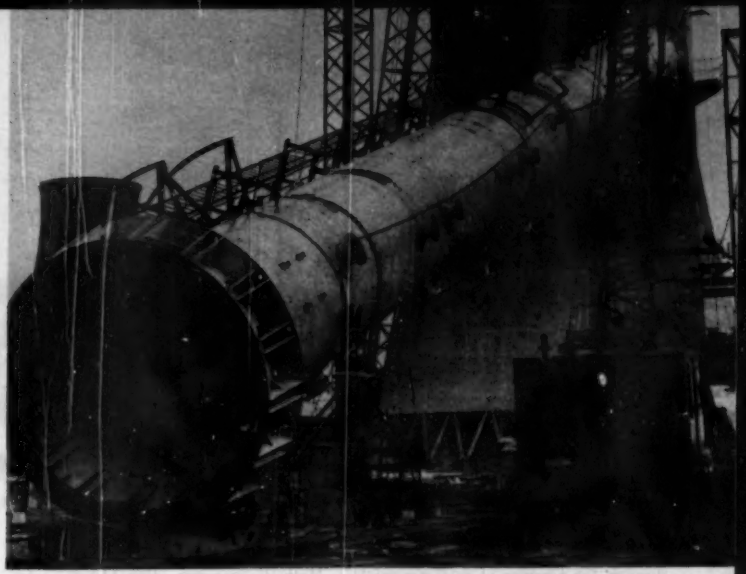

Figure 1. Giant New Absorption Column Being Raised at Shell's New Stanlow (Cheshire, England) Refinery.

THE paramount part played by petroleum in the economic recovery of Europe is revealed by two reports released late in August—"Economic Progress and Problems of Western Europe" by O.E.E.C., and the "Second Report on the Coordination of Refinery Expansion in Europe" by the oil committee of the O.E.E.C. The Marshall Aid program indeed gave the much-needed blood transfusion to war-stricken Europe, and the patient responded to the treatment so well that he has achieved in three years nearly all that was hoped in for.

Increase in output of refined oil products by Western Europe during the period was proportionately greater than with any other commodity; it amounted to 200 percent. Oil companies operating in the region also made a valuable contribution to the O.E.E.C. countries in that earnings from their overseas activities greatly augmented the "invisible" items which made possible a great improvement in their external balance of trade. Consumption of petroleum products by "Marshall Europe" (excluding bunkers) rose from about 26 million metric tons before the war to 35 millions in 1947 and 44 millions in 1949-50. This increased intake was met by the development of crude oil output, and construction of new and extension of existing refineries. Motor fuel consumption of Western Europe, at 28 percent of the total, restricted first by rationing and later by increased excise duties in several countries, has only recently reached prewar level. There was a marked growth in the intake of gas and diesel oils following mechanization of agriculture, increased employment of commercial vehicles and partial change from steam to Diesel engines on European railways. The greatest proportionate rise has been in fuel oil now forming a third of the total, and in some countries more than half. What was correctly regarded in 1949 as a fuel marginal or supplementary to solid fuels must now be deemed an essential contribution to the sources of European energy. Without adequate energy supplies European economic and industrial activity cannot fail to be checked.

The O.E.E.C. Oil Committee's new (1951) estimate of refinery thruput for Europe in 1952-53 is 65.1 million metric tons, against its original (1949) figure of 62.4 millions. Net currency saving from the implementation of this program is difficult to assess, but the committee is of the opinion that a gross currency saving of approximately $450 million (accounting currency) can be achieved. As part of the E.R.P. oil had a particularly important role to play, but the specific dollar outgoings on account of petroleum in 1948 were calculated on a f.o.b. basis at about $500 million with an over-all foreign exchange cost of approximately $1000 million on an f.o.b. basis, and exclusive of extra-European trade. A cardinal feature of O.E.E.C.'s oil policy to reduce this dollar burden was a major expansion of crude oil refining facilities. Inland oil consumption as estimated by the committee in million metric tons is for 1950-51, 51.7; 1951-52, 56.3 and 1952-53, 60.9. Inland demand rose by 17 percent between 1948-49 and 1949-50, by 18 percent between 1949-50 and 1950-51, and will continue to rise by nine percent the following year and eight percent the year after.

Table 1 gives the estimated refinery thruput of Western Europe in 1952-53 in million metric tons by countries.

Since by far the largest postwar oil refinery expansion of all Western European countries under way is in the United Kingdom, Table 2 makes interesting reading.

Apart from thruput changes there has

TABLE 1
Estimated Thruput Refinery Western Europe
(in million metric tons)

	First Report (1949)	Second Report (1951)
U. K.	19.35	21.33
France	18.78	16.95
Italy[1]	8.12	9.68
Benelux	8.26	8.04
Germany	4.72	6.34
Sweden	1.34	1.25
Austria	0.62	0.98
Portugal	0.37	0.32
Switzerland	0.10	0.10
Turkey	0.06	0.06
Norway	0.04	0.04
Denmark	0.03	0.03
Greece[2]	0.4	....
Total	62.39	68.12

[1] 1951 estimate includes Trieste; that for 1949 included only part Naples and Trieste refineries.

[2] 1951 estimate shows that Greek projects have been deferred.

TABLE 2
Annual Thruput of Individual U. K. Refineries (in 1000 metric tons) in 1952-53.

	First Report (1949)	Second Report (1951)
Esso Petroleum, Fawley	5,568	6,190
Shell, Stanlow	2,807	3,482
Anglo-Iranian, Llandarcy	2,337	2,723
Shell, Heysham	1,605	1,851
Anglo-Iranian, Grangemouth	1,219	1,588
Vacuum, Coryton	....	425
Anglo-Iranian, Pumpherston	153	173
Shell, Ardrossan	....	155
Lobitos, Ellesmere Port	254	152
Manchester Oil Refinery, Partington	102	122
Berry Wiggins, Kingsnorth	145	65
Berry Wiggins, Weaste		54
William Briggs, Dundee	30	34
Shell, Shellhaven	3,201	2,280
Anglo-Iranian, Kent	1,372	7052
Total	23,365	25,656
Project included for information: Caltex, Trinidad Leaseholds	560	....
GRAND TOTAL	23,924	25,656

Figure 2. General View of Esso Petroleum's New Refinery at Fawley, England, Formally Opened on September 14.

been a noteworthy development in the character of plant installed, mainly through the advance of catalytic cracking, which converts heavier fractions like gas oil into more valuable, and hence desirable, lighter motor gasolines. See Table 3.

The total cost of European refinery expansion over 1948-54 is estimated $1,018 million (accounting currency), of which about $169 millions represent actual dollar expenditure. Up to date E.C.A. has financed wholly, or partly, no less than 12 refineries involving $35 million of aid, as shown in Table 4.

Whereas before the war dollar crude oil imports were 53.3 percent of European refinery requirements, by 1952-53 this proportion will have been reduced to 19.8 percent, and non-dollar crude supply will have risen from 46.7 percent in prewar time to 80.21 percent in 1952-53. Also, by the latter period indigenous output of crude petroleum and shale oil will total four million tons, meeting some six percent of Western European refinery needs. Intra-European trade is of great value for the disposal of finished products. It is reckoned to account for about 10 percent of the total output from European refineries in 1952-53.

Turning to quality, as a rule the octane rating of gasoline in Europe is 70-72 (Motor Method). Certain countries are, however, importing 74-76 (Motor Method) gasoline. The O.E.E.C. Oil Committee feels that a progressive improvement of this rating by a few points would be justified, considering that in the United States ordinary gasoline has an octane rating of 78, and premium grade, 82. The programs of participating countries, by making extensive use of catalytic cracking technique, will provide, by virtue of reserve capacity or operational flexibility, the possibility of processing about another 10 million tons of crude oil a year on completion of all approved projects.

TABLE 3
Oil Cracking Capacity of European Refineries

	(In Metric Tons per Stream Day)			
	Catalytic Cracking		Thermal Cracking	
	On Dec. 31, 1952	On Completion	On Dec. 31, 1952	On Completion
U.K.	11,170	12,670	1,520	1,520
Benelux	2,500	5,510	8,190	8,190
France	2,100	7,870	2,530	2,530
Germany[1]	4,109	5,624	3,216	3,216
Italy	1,610	2,210	3,490	3,490
Total	22,489	33,884	18,946	18,946

[1] To these should be added 2,848 tons per stream day for hydrogenation plants.

Before the war Western European refineries had an annual output of 11.2 million metric tons, when half of the oil supplies were paid for in dollars. By 1952-53 the thruput capacity will be five times gerater, and the additional oil supplies, of approximately 44 million tons, will be obtained with little increase in dollar imports of crude oil or finished products, and with a substantial saving in currency. The benefits accruing from this great physical and financial investment cannot be measured merely by the saving in foreign currency, important as that may be. Europe gains a basic industry capable of supplying liquid fuels, lubricants and a wide range of valuable petrochemicals vital to its economic life. Up to the end of April, 1951, E. C. A. has provided $1,200 million in the supply of oil and equipment to Western Europe, and the time is rapidly approaching when the refining industry of this important region will be able to provide the major part of the oil products needed by the participating countries.

Although this region's refinery thruput will supply close on 59 million tons of oil products in 1952-53 toward the 61 million tons required for inland consumption, there will still be a net deficit of about 11.4 million tons to meet bunker deliveries, supplies to overseas territories and exports to non-participating countries. With E. P. U. (European Payments Union) making for greater liberalization of trade the exchange and flow of petroleum products between participants is reckoned to reach 10 percent of the refinery output in 1952-53. The development of domestic refining and the financial agreements entered into between certain participating countries and some United States companies will provide the former with oil needed in 1952-53 at a substantial saving in currency.

The oil committee lays down that for future refinery projects the criterion, whether they can operate economically in face of competition without excessive fiscal or administrative protection, will assume cardinal importance. Extensions of plant and new units are already in construction which will increase the output from European refineries after 1952-53. The continuing rise in world-wide demand for petroleum products is compelling oil companies to plan for the future. While recommending that wasteful duplication of refining facilities should be avoided, and the development of refinery expansion should be kept under continuous review by the O. E. E. C. to ensure orderly progress, the oil committee is not in favor of restricting European refining capacity to a "ceiling," in view of the universal rising trend in consumption of liquid fuel products and petrochemicals.

TABLE 4
Oil Investment Program of O.E.E.C. Countries, 1948-54

	Expenditure	Non-Expenditure (In 1,000)	Total
U.K.	66,900	362,700	429,600
France	25,967	181,650.5	207,217.5
Italy	30,299	107,213	137,512
Benelux	30,794	86,206	117,000
Germany	3,925	88,145	92,070
Others	11,025	23,668.7	35,083.7
Total	169,110	849,383.2	1,108,493.2

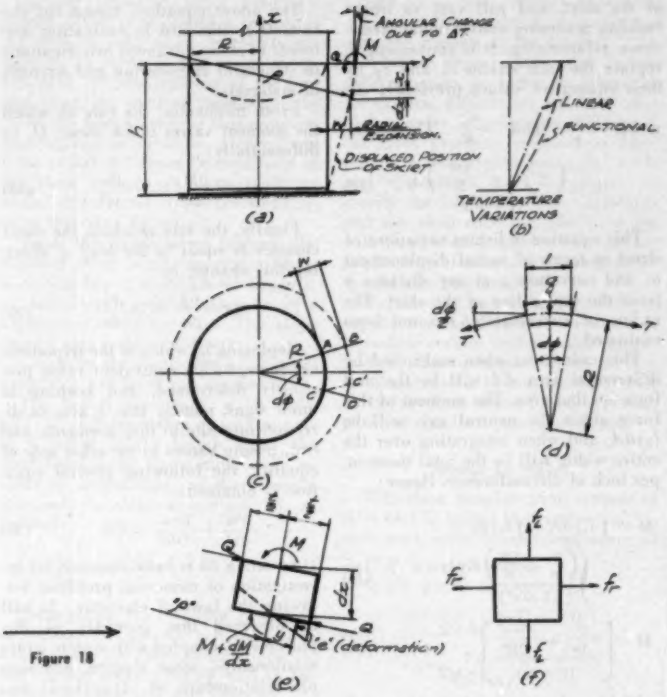

Figure 18

Supports for Vertical Pressure Vessels

PART IV

F. E. WOLOSEWICK

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THIS IS THE concluding part of Mr. Wolosewick's discussion of supports for vertical pressure vessels, a subject about which comparatively little information has been published. Part I appeared in July, Part II in August and Part III in the October issue.

Pressure vessels in process plants are subjected to varied conditions and these changes in operating temperature and pressure induce stresses, sometimes quite large, in the support structures. These are the problems treated in the current four-part series, one that has been welcomed by those in the industry concerned with pressure vessel design, fabrication, inspection and maintenance.

Stresses in Skirts Due to Thermal Expansions

ASSUMING that the temperature gradient through the skirt is known approximately, it is possible to estimate the probable ranges of stresses which could be developed at the weld line.

In the development which follows, use is made of the concept of beam on elastic foundation, which has been mentioned repeatedly in this article. The application of this tool of analysis is predicated on functional and elastic displacements; on assumption of linear stress distribution through the wall and on the recognition of modulus of elasticity.

In highly stressed members operating at elevated temperatures, flow of metals or creep will occur, and the simple linear stress distribution would no longer be true. Some metallurgists question the present values of modulus of elasticity, while others indicate that plasticity of metals modifies stresses computed on the elastic premises. A list of some recent researches in these fields is included in the bibliography.

These and many similar ideas throw considerable doubt on the elastic method of analyses. Unfortunately most of these ideas are in a discussional and experimental stage. Coalescence of these ideas, by scientists, metallurgists and research groups into a simple workable analytical tool for practicing engineers is eagerly looked for. Until some definite formulations can be presented, the present theory of elasticity constitutes the only available method of analysis of these and similar problems.

Use of Beam on Elastic Foundation

The basic idea of beams on elastic foundation was established by Winkler in 1867, in studying stresses in rails, extended by Zimmerman in 1888, and summarized by Timoshenko and Hetenyi respectively in *Theory of Plates and Shells*, and *Beams on Elastic Foundations*.

Consider an elementary height of the skirt of differential height dx, undergoing exaggerated symmetrical radial displacements, under the action of heat. There is then a radial displacement of w, with corresponding increase of the circumference by an amount of $C'D$, for any differential angle of $d\phi$ as shown in Figure 18. Similarly a differential element above and below the one considered will undergo a radial displacement, but of varying degree.

The differential elements are continuous longitudinally, that is perpendicular to the plane of the paper, hence circumferential shears and moments will be developed along the length of the skirt due to continuity.

To evaluate moments and shears it is necessary to determine the manner in which displacements w varies longitudinally. This can be done by expressing displacements w differentially.

For any small angle $d\phi$, length of arc $AC = Rd\phi$. For change in radius by an amount of w, arc $BD = (R + w)\, d\phi$. The difference between AC and BD is $C'D$. Or $C'D = (R + w)\, d\phi - Rd\phi = wd\phi$.

If AC is assumed as unity, then the

ratio of $C'D$ divided by AC, will be the unit strain per unit of length. But $AC = Rd\phi$, or $1 = Rd\phi$. Therefore unit strain, due to radial displacement of w,

$$e_R = \frac{C'D}{AC} = \frac{w\,d\phi}{R\,d\phi} = \frac{w}{R} \qquad (14)$$

Due to radial displacement w, hoop force T is acting on an element AC causing a stretch of $C'D$. Force T can be replaced by a horizontally distributed force q, assumed to be acting over the length of unity. Hence, $T = \frac{q}{d\phi}$.

Assuming Modulus of Elasticity to apply,

$$E = \frac{\text{Unit stress}}{\text{Unit strain}} = \frac{qR}{d\phi tw} \qquad (15)$$

Replacing $d\phi$ by its equivalent, $1/R$, substituting,

$$E = \frac{qR^2}{tw} \qquad (16)$$

$$\text{Hence} \quad q = \frac{Etw}{R^2} \qquad (17)$$

This fictitious force q varies continuously along the height of the skirt. To determine the variation of this force, it is necessary to consider the manner in which the skirt bends.

For any differential height of the skirt, let ρ be the curvature. From relationship of similar triangles shown in Figure 18e, $dx : \rho = e : y$. Rearranging algebraically, the unit stretch along the length of the skirt is $e_L = \frac{e}{dx} = \frac{y}{\rho}$. This stretch is resisted by material at point A and C in the plan view of the element. Hence assuming Poisson's ratio v to apply, the unit longitudinal strain will be modified to the extent of resistance offered by radial displacement. Consequently, the net unit stretch becomes:

$$e'_L = e_L - ve_R$$

The next step is to determine stress relationships in terms of unit displacement. This can readily be done by application of modulus of elasticity. Hence the two unit strains, one in the longitudinal direction, the other in the radial direction are as follow:

$$e'_L = \frac{f_L}{E} - v\,\frac{f_R}{E} \qquad (18)$$

$$e'_R = \frac{f_R}{E} - v\,\frac{f_L}{E} \qquad (19)$$

From the above two equations, unit stresses in both directions are obtained:

$$f_L = \frac{E\,(e'_L + ve_R)}{(1 - v^2)} \qquad (20)$$

$$f_R = \frac{E\,(e'_R + ve'_L)}{(1 - v^2)} \qquad (21)$$

The stress f_L is the longitudinal bending stress, through the thickness of the skirt, and will vary in linear fashion, assuming conventional stress-strain relationship. It is convenient to replace the unit strains e_L and e_R by their equivalent values previously derived, $\frac{y}{\rho}$ and $\frac{w}{R}$. Therefore:

$$f_L = \frac{\left(\frac{y}{\rho} + \frac{vw}{R}\right)E}{(1 - v^2)} \qquad (22)$$

This equation indicates variations of stress in terms of radial displacement w, and curvature ρ at any distance y from the center line of the skirt. The radius of curvature ρ, has not been evaluated.

This unit stress when multiplied by differential area dA will be the unit force on that area. The moment of this force about the neutral axis will be $f_L y dA$, and when integrating over the entire width, will be the total moment, per inch of circumference. Hence:

$$M = \int f_L y dA = \int f_L y dy = \int \frac{\left(\frac{y}{\rho} + \frac{vw}{R}\right)E y dy}{(1 - v^2)} \qquad (23)$$

$$M = \left[\frac{\frac{y^3}{3\rho} + \frac{vwy^2}{2R}}{(1 - v^2)}\right]_{-t/2}^{+t/2} \qquad (24)$$

Making the above substitutions, collecting terms, the following equation, standard in Elasticity, is obtained:

$$M = \frac{Et^3}{12\rho\,(1 - v^2)} = \frac{Et^3}{12\,(1 - v^2)} \times \frac{1}{\rho} = \frac{D}{\rho} \qquad (25)$$

The second term of equation 24 becomes zero as a consequence of integration, leaving only the first term to resist curvature longitudinally. It is convenient and in line with accepted usages to define the elastic constants of equation 25 by D. Hence the more convenient restatement of equation 25, is written in this fashion:

$$\frac{1}{\rho} = \frac{M}{D} \qquad (26)$$

Curvature is conveniently expressed in differential form in terms of rate at which the slope changes, per unit of distance. The slope is expressed as an angle, in this instance it would be expressed as the change in radial expansion w, or dw/dx. Therefore the rate of change of slope would be $d^2w/dx^2 = 1/\rho$. Making the above substitution of curvature in terms of rate of change of slope due to expansions radially, the following differential equation of the second order is obtained:

$$M = D\,\frac{d^2w}{dx^2} \qquad (27)$$

The above equation, except for the term D is standard in evaluating moments in many advanced investigations in structural engineering and strength of materials.

From mechanics, the rate at which the moment varies is the shear, Q, or differentially:

$$Q = \frac{dM}{dx} = D\,\frac{d^3w}{dx^3} \qquad (28)$$

Finally, the rate at which the shear changes is equal to the load q affecting this change, or:

$$q = \frac{dQ}{dx} = D\,\frac{d^4w}{dx^4} \qquad (29)$$

Replacing q, which is the hypothetical force, by its equivalent value previously determined, and keeping in mind signs, namely that q acts in direction opposite to displacements, and transposing values to the other side of equality, the following general equation is obtained:

$$\frac{d^4w}{dx^4} + \frac{Etw}{DR^2} = 0* \qquad (30)$$

Equation 30 is basic equation for investigation of numerous problems following the laws of elasticity. It will be observed that geometry of displacements, coupled with simple strain relationships, some algebra, and simple relationships of structural mechanics were necessary to determine the above relationship.

Mathematical Solution

Mathematical solutions of the above equation belong to the realm of pure mathematics, and will not be presented here, because of their intricate mathematical manipulations. The final solutions for displacements, and rotations of the top of the skirt in terms of the moment M, and shear Q, per unit of length are expressed as follows:

$$\text{displacement radially } w = -\frac{1}{2B^3D}(BM + Q) \qquad (31)$$

rotation of skirt in terms of radical expansion w:

$$\frac{dw}{dx} = \frac{1}{2B^3D}(2BM + Q) \qquad (32)$$

where $D = \frac{Et^3}{12\,(1 - v^2)}$

$$B = \left(\frac{3(1 - v^2)}{R^2t^2}\right)^{1/4}**$$

*In order to avoid mathematical difficulties, this equation is generally expressed in this manner: $\frac{d^4w}{dx^4} + 4B^4w = 0$

**and may be found in Timoshenko's *Advanced Strength of Materials*, and in slightly different form in Hetenyi's *Beams on Elastic Foundations*. B is defined as the flexural rigidity of the beam as well as the elasticity of supporting medium, and is an important factor in influencing the shape of the elastic line. Quoted from Hetenyi's *Beams on Elastic Foundation*.

As the vessel is being gradually heated, there is an increase in diameter, and as long as no restraints are offered, no stress in the vessel is anticipated. At the junction of the bottom head, the vertical vessel, and the skirt, the temperature at this common meeting line is the same. Hence there is no radial difference in expansion of the three component parts, and the radial differential displacement w, must therefore be zero.

From this point down towards the support, there is a temperature variation, whether it is expressed linearly, or functionally, which tends to give an angular tilt to the skirt. This slope can be expressed as follows:

Let a, be the coefficient of thermal expansion per inch, per degree °F.

The radial expansion, w, is $w = aRT$. By differentiating w, with respect to x, which is the length along the skirt toward the foundation, with respect to temperature, as the variable assumed, the slope at any point is as follows:

$$\frac{dw}{dx} = \frac{aRdT}{dx} \qquad (33)$$

Substituting the limiting boundary conditions for $w = 0$, and the above equation for the slope in equations 31, and 32, and solving for M, and Q, the following equations are obtained:

$$M = 2BDaR\frac{dT}{dx} \qquad (34)$$

$$Q = 2B^2DaR\frac{dT}{dx} \qquad (35)$$

Simplifying the above equation for bending moment M, for determining the unit stress in bending f, the following equation is obtained:

$$f = 1.33\frac{\sqrt{3(1-v^2)}}{1-v^2} \cdot \sqrt{Rt}\, Ea\frac{dT}{dx} \qquad (36)$$

In the above equation a number of quantities were assumed to be constant, and also one boundary condition was assumed to be zero. Thus Poisson's ratio v, varies with temperature in a parabolic fashion.[27] Modulus of elasticity[27] is not constant, but has functional relationship with temperature. Likewise the coefficient of linear expansion varies with temperature.[27]

Due to discontinuity stresses from pressure, there is also a slight angular tilt at the tangent line which relieves the moment due to temperature variation. This slight angular slope was assumed to be zero, thereby increasing somewhat the resulting moments and also the stresses at the tangent line.

Whether these factors need further differentiation in order to formulate an explicit differential equation of a higher order is somewhat problematical from practical engineering viewpoint. Considerable research, study and discussions are necessary to clarify the extent of these variations, and also their resulting effects. In line with these considerations, such factors as plasticity of metals,[18,20,21] and creep[14] should also be considered

Inclusion of variations of elasticity, expansions and Poisson's ratio would introduce certain undersirable mathematical consequences. Hence in this article, for sake of convenience, these variations were ignored, and only temperature gradient was considered.

Stress in Skirt

With these simplification stresses in skirt of 130 inches in diameter, of ½-inch wall, with metal temperature of 700° F. were evaluated.

At the above temperature,

$$v = 0.27,\ E = 25.5 \times 10^6,$$

and

$$a = \frac{7.6 \times 10^6}{\text{inches}/°F,}$$

Making these substitutions, the unit flexural stress f from Equation (38) is approximately 9350 psi.

For skirts of different thicknesses, of the same mean radius and operating at the same temperatures, stresses at the tangent line are as follow:

For 1-inch skirt, f = 13,500 psi.
For 2-inch skirt, f = 18,700 psi.

In addition to moment, radial shear Q is also acting around the complete circumference. The effect of this radial shear is to decrease the diametral expansion, and to introduce secondary variations in the radial expansion w. In other words the simplicity of boundary conditions, by making radial displacement w dependent solely on functional moment relationship, is slightly beclouded by presence of shear detrusions.

Generally these shear effects are of no consequence in thin skirts, and in thin walled vessels. They do become of some consideration when thicknesses are considerable. It may be said in passing that when such investigations should be attempted, that thicknesses of bottom heads, and walls become of prime considerations.

From the above equations radial shear Q for various thicknesses of skirt are tabulated below:

Q = 84 pounds for ½-inch skirt, of 130 inches diameter
Q = 340 pounds for 1-inch skirt, of 130 inches diameter
Q = 2680 pounds for 2-inch skirt, of 130 inches diameter

From the shear acting, the average shear per unit of area can be determined, by dividing the force by the unit area over which it acts. Thus for a skirt of ½-inch thickness the unit shear becomes 168 psi, while for the two-inch thick skirt, the unit shear would be 1340 psi.

The above bending and shear stresses were computed on the full thickness of supporting metal. When welds are used having the full thickness of the skirt, no stress increase should be anticipated. For those welds where the skirt is on the outside of the vessel, stress conditions would be considerably aggravated.

Hence from this analysis this type of construction does not appear to be desirable as the one where the center line of the skirt is coincident with the center line of the cylindrical portion of the vessel.

The above stresses are maximum on the basis of assumptions used in this article. At distances away from the tangent line, temperatures are lower, rates of expansions are smaller, strength of metal is greater, therefore stresses at those levels do not appear to be of such importance as those at the tangent line.

Conclusion

The above study of stresses in skirts and vessels due to concentrations and temperature effects should be viewed as an approximation. The various equations expressing moments due to concentrations are based on simplifying assumptions, used frequently in various engineering fields, where, either through lack of experimental data, or mathematical difficulties, approximate working rules are established, to be used with caution and judgment.

It is unfortunate from design engineer's viewpoint, that these complex problems are glossed over in general terms by the code authorities, leaving the entire subject to the judgment of the individual.

End of Part IV and series.

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Note—The author, Mr. Wolosewick, is connected with Sargent and Lundy, Engineers, Chicago.

**Solutions of these equations, with slightly different nomenclatures will be found in Timoshenko's *Theory of Plates and Shells*, and *Advanced Strength of Materials*. Also see Hetenyi's *Beams on Elastic Foundations*. In addition to longitudinal bending stresses, there are also bending stresses through the thickness of skirt affected by Poisson's ratio.

Shell Refinery At Berre, France, Greatly Expanded

General View of Shell Berre Refinery Showing the High Vacuum and Redistillation Plant to the Right, the Pipe Platform in the Center, and the Filter Oil Concentration Plant to the Left.

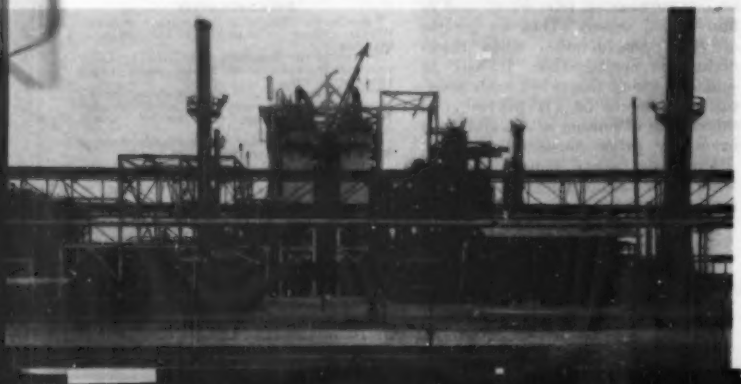
IN 1947, under the spur of French post-war plans for industrial rehabilitation, La Compagnie de Raffinage Shell Berre was formed with capital subscribed in the proportion of 60 percent by Shell Francaise and 40 percent by P.C.R.B. (Compagnie des Produits Chiniques et Raffineries de Berre). P.C.R.B. operated a refinery at Berre-d'Etang since 1931, and Shell Francaise had the two plants of Petit Couronne (Rouen) and Pauillac (Bordeaux), both badly damaged during World War II.

The refining resources of the two companies were pooled under the aegis of La Compagnie de Raffinage Shell Berre, and the three plants operated by it. In 1948 Shell Berre treated 2,225,000 metric tons of crude and in 1949, 2,754,000 metric tons. In 1951 the capacity of the three refineries was running well above 79,044 barrels per day, or close to a quarter of the French refining capacity. The expansion project now under way at Berre will bring its eventual capacity to 2,500,000 metric tons a year.

The Shell Berre refinery is situated on the landward shore of Etang de Berre, and a 14-inch pipe line, running 25 miles along the east shore of the lake and across an artificial "spit," links the Shell Berre storage tanks with the refinery. At Lavera tankers of up to 18,000 tons can discharge crude oil to the storage tanks through sea-lines, and docks are now being built to accommodate up to seven 24,000-ton tankers at a time. Crude storage capacity is now 3,774,000 barrels. The refinery is well situated, adjoining the main Marseille-Paris railway line and road, accessible to the canal and coasting trades, and about 1500 miles from Suez.

The crude treated at the refinery is drawn mostly from Kuwait, but it is supplemented by oil from Dificil (Colombia), Iraq, Tarakan, Sidi Aissa (Algeria), Seria, Lagunillas, and Lagunillas-Tia Juana (Venezuela) and Lacq (the French field near Pau). The refinery comprises a high-vacuum distillation unit a small topping unit, an acid treating plant for lube oils, a small reformer, a lube oil blending plant, a paraffin wax plant, a treating plant for special white products, and a bitumen plant. To these were recently added a new 43,500 barrels per day topping unit and a 8700 barrels per day reformer, which have been on stream since the summer.

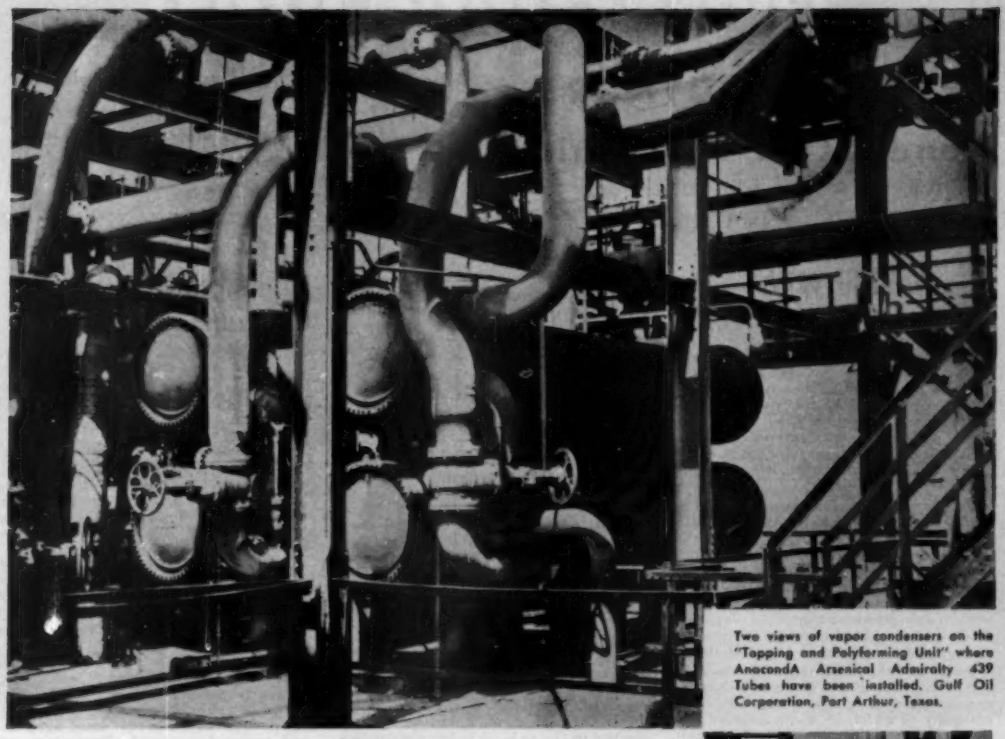
Houdry Catalytic Cracking Unit at Berre.



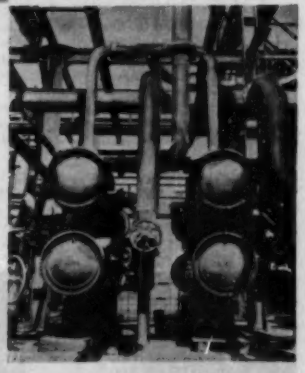
A new fluid catalytic cracker is to be installed, and should be in operation in 1952. The present cracker at Berre is a Houdry fixed-bed type. It was ready for erection in 1940, but the war prevented and it was not put into operation until 1947. This fixed-bed plant is relatively expensive to operate, in view of later developments in this field, since the three reacting chambers have to be taken out of service in turn for regeneration and evacuation. The Fluid catalytic cracker, besides being cheaper to operate, is better suited to deal with the high-sulfur-content crudes forming the bulk of Berre's intake.

All the auxiliary services are being augmented to deal with the enlarged capacity of the refinery. The supply of steam from the boiler house has been stepped up to 200 tons an hour, and the electricity generating capacity is now 14,000 kw per hour. There is a proposal to build a canal from the Durance to the Etang de Berre for generating hydroelectricity, and the refinery could expect to share in the benefits when this scheme materializes.

The Shell Berre refinery will yield a wide range of products roughly in the following proportions: heavy fuel 30 percent, automotive gasoline 20 percent, gasoil 11 percent, light fuel 10 percent, bitumen 5 percent, aviation gasoline 2 percent and kerosine 2 percent. The balance is made up of lube oils, butane, special boiling point, paraffin wax and other miscellaneous items.



Two views of vapor condensers on the "Topping and Polyforming Unit" where AnacondA Arsenical Admiralty 439 Tubes have been installed. Gulf Oil Corporation, Port Arthur, Texas.



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REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the processing industry.

He's In Love With Natural Gasoline Work

The author of "Rich Oil Rectification" which begins on page 143, contributed his first paper in 1927 before the C. N. G. A. Since then Edward G. Ragatz has had many papers published and made many technical contributions, one of which was the "Straight-Line Chart" method of evaluating absorber performance.

Ragatz adopted the natural gasoline field as his "love" way back in 1921 when he first graduated from M.I.T. with a B.S. in mechanical engineering. For 18 years he did process research and development work for the Union Oil Company, became closely associated with many important process developments in the natural gasoline operations, and published details of many of them.

Early in 1942 he temporarily deserted the petroleum field to assist in the rapid expansion of a specialty machine tool company of which he was a founder and third owner. The company developed and manufactured a series of machine tool accessories which contributed markedly to mass production of aeronautics.

Since then he has been associated with Bechtel Brothers-McCone Parsons as liaison engineer on a large war-time project at the refinery at Curacoa, Netherlands West Indies, and as head of a natural gasoline division.

During the past few years, Ragatz has operated as an independent consultant and absorption specialist, and is also associated with the J. B. Gill Company. Natural gasoline processing is his "first love" and his "favorite hobby," being rated above his other pastimes of duck hunting and trout fishing with his two boys.

SOD Industrial Expert Writes on New Process

An international authority on the industrial application of chemical engineering, Eger V. Murphree is author of the section of "Fluid Hydroforming" which deals with fundamentals, cost and application as found on page 97. President of the Standard Oil Development Company since 1947, Murphree first joined the Standard organization in 1930 to develop chemical processes employing petroleum fractions as raw materials.

He is credited with contributing to a large number of petrochemical developments, including fluid catalytic cracking, 100-octane gasoline, synthetic toluene, butadiene and hydrocarbon synthesis. At last given count he held 13 patents in the field of industrial application of chemical engineering.

Awardee of the Perkin Medal for 1950, Murphree also distinguished himself for service with the Office of Scientific Research and Development as a member of the S-1 Executive Committee. This was the committee instrumental in developing the Manhattan Project. To name just one project, he supervised the design for a heavy water plant in British Columbia, and was responsible for much of the work on the centrifugal method of separating uranium isotopes.

Huntington's Athletic Co-Author Hobbling

R. L. Huntington has teamed up with John M. Campbell for his current series of articles, "Heat Transfer and Pressure Drop in Fixed Beds of Spherical and Cylindrical Solids," which begins on page 127.

Huntington has been contributing to the PETROLEUM REFINER for over 17 years and is an old friend to all readers. His latest series on "Pressure Drop Through Bubble Caps," done with the assistance of J. L. Huitt, was concluded in the October issue.

A graduate of M.I.T. and the University of Michigan, he spent 12 years working in a natural gasoline plant and gaining refining experience in operation and design. He began teaching at Oklahoma University in 1933.

Co-author Campbell, usually engaged in athletic pastimes, is in a forced state of inactivity because he recently sprained his ankle while participating in a spirited scrimmage with his two sons, aged five and two-and-one-half! (Texas fans can look forward to a top season along about 1966.) Campbell's activities as an Oklahoma high school official presumably must wait until his ankle is pronounced whole.

He graduated with a B.S. in chemical engineering from Iowa State College in 1943 and then accepted a position with Du Pont at their cleveland plant. He was soon transferred to the atomic energy installation, but left Du Pont in 1946 to become an instructor in chemical engineering at Oklahoma University.

In 1950 he resigned his instructorship

Edward G. Ragatz

Eger V. Murphree

John M. Campbell

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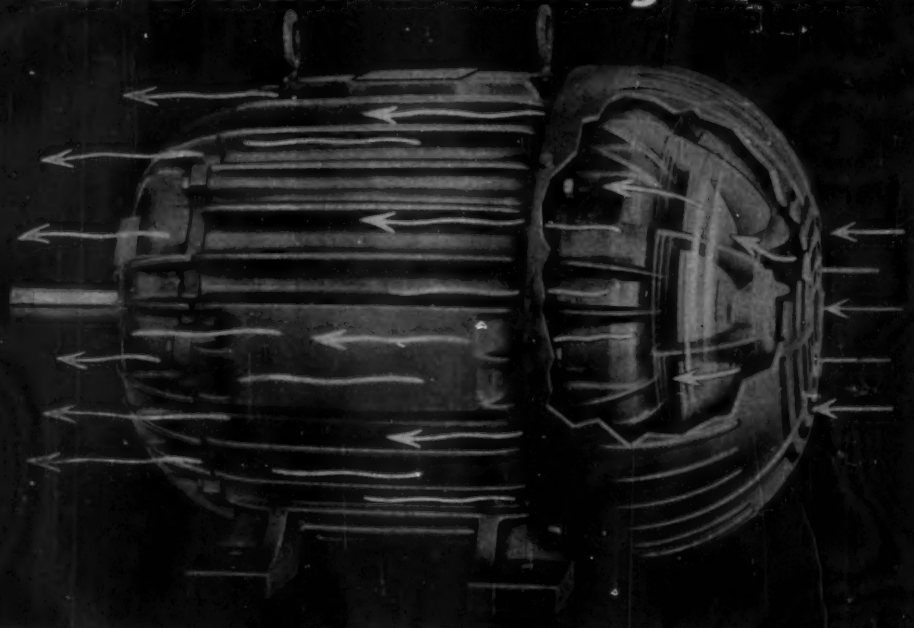

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Ray H. Horton

Henry G. McGrath

W. W. Boyd

to complete work on a Ph.D. which he received last June. While instructing at O.U. he did research under a grant from the Gulf Oil Corporation and also did some catalytic work for the Aluminum Company of America. He began working for Black, Sivalls & Bryson, Inc., on special dehydration problems in 1950, and is at the present time engaged as technical assistant to the Oil and Gas Sales manager of that company.

Geologist Directs Employe Relations

When he began his oil career 27 years ago, Ray H. Horton, author of "Fundamentals of an Employe Relations Program" on page 109, accepted a job as a rotary helper with the Morter Drilling Company at Ardmore, Okla. After working with several independent drilling contractors during school vacation periods, he joined Humble in 1930 as a rotary helper on a core drill engaged in obtaining geologic information.

Currently industrial relations manager for Humble Oil & Refining Company, Horton graduated from the University of Oklahoma with a B.S. degree in geology.

In 1932, with the inception of the industrial representation plan, Horton served as chairman of the Employes' Representative Council until appointed safety engineer for Humble's operations in the Gulf Coast Division. Transferred to the Training division of the Industrial Relations department, he conducted conferences for foremen in various field operations. From regional industrial relations manager in 1935, to policy coordinator for Production in 1945, he was appointed to his present position in 1946.

Horton, who during World War II served as chairman of PAW's Production Manpower Committee for District III, is a member of the executive board of the Sam Houston Area Boy Scouts of America and of the Industrial Personnel Association.

Process Careerist Has Development "Bent"

A key figure in The M. W. Kellogg Company process development program, Henry G. McGrath is the author of the economic and performance aspects of the "Fluid Hydroforming" article found on page 102. A Kellogg veteran of 14 years, McGrath is now the associate director of the Petroleum and Chemical Research Laboratory.

Kellogg reports that McGrath has played an increasingly important role in their process development program, concentrating primarily on hydroforming, gasoline synthesis and the application of the Fluid catalyst technique to chemical processing generally.

Beginning his career as a pilot plant operator in 1937, McGrath proved his bent for development work, and at the outbreak of the war he concentrated upon improving the hydroforming process utilized to make toluene explosives and aromatic blending agents for high octane aviation gas. Kellogg gives him "major" credit for the succesful development of Fluid catalytic processing.

Author of many technical papers on petroleum refining and chemicals production and recovery, and holder of many patents in these fields, McGrath holds both B.S. and M.S. degrees in chemical engineering from M. I. T.

Married and the father of two children, McGrath names swimming and skiing as his principal hobbies.

Hobbyist Has Own Basement Workshop

"Spiral-Wound Gaskets on Flanged Joints" beginning on page 120 is the work of W. W. Boyd, field engineer for Flexitallic Gasket Company, who has operated from Tulsa headquarters since 1937.

A native of Alabama, he graduated from Auburn (Alabama Poly) in 1911 and spent the next six years in engineering and sales work with a foundry. Following military service during World War I he sold boiler and power plant equipment and sugar mill machinery in Havana, Cuba, serving simultaneously as the agent for Flexitallic gaskets in Cuba. Transferred to Flexitallic's Tulsa area in 1937, Boyd has built up a solid reputation of being an authority on refinery applications.

Boyd's hobbies led to the installation of a hobby shop in his basement, and he spends much of his free time there, though he also is interested in golf and hunting.

Executive Sponsors Tulsa Philharmonics

The interests of Dr. I. A. Anson, author of "The Engineer's Special Interest in Finance" on page 124, range from his petroleum career to philharmonics and classic literature. President of Ben Franklin Refining Company and vice president of Bell Oil and Gas Company, his executive professional career began with the Midco Petroleum Company in 1919-1921 as assistant secretary. In 1921-1934 he was associated with Altitude Petroleum Company of which he became president. When this company merged with Bell Oil and Gas, Dr. Anson was named vice president of the merged companies.

Dr. Anson was named a director of the Tulsa symphony in 1948 and has continued his activities with philharmonic groups since then; he is also a trustee of the Philbrook Art Center, and a member of a monthly society which reads such authors as Shakespeare, Homer, Dante, etc. In addition Dr. Anson has been active in Little Theater groups.

A patent dealing with hydrocarbon process was granted Dr. Anson in 1937 and was subsequently acquired by Standard of Indiana. This friend of the arts holds degrees from Columbia University, M.A., Johns Hopkins University, Ph.D. in political science, and an extension study in petroleum engineering at Tulsa University.

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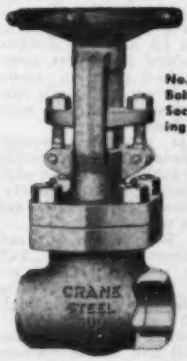

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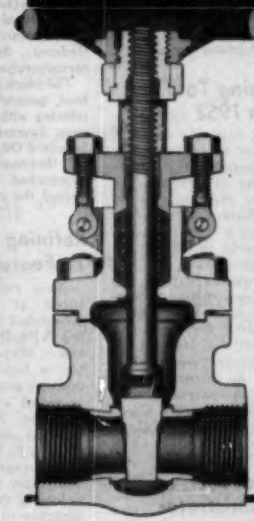

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The MONTH... in the INDUSTRY

OIL WEEK INSPECTION of the Destrehan, La., refinery where a multi-million dollar expansion and improvement program is underway, was followed by a week-end of relaxation at Grand Hotel, Point Clear, Ala., for officials and directors of the Standard Oil Company (Indiana) and its subsidiary, Pan-Am Southern Corporation. The group was transported to Point Clear from New Orleans on the yacht Pudlu.

The photo above shows, left to right: D. P. Hamilton, director Pan-Am Southern and owner of Pudlu; R. L. Aycock, general manager for Bulk Sales, Pan-Am Southern; Bruce K. Brown, president and director, Pan-Am Southern; Dr. Robt. E. Wilson, chief executive officer and chairman of board, Standard Oil (Indiana); Bentley G. McCloud, director, Pan-Am Southern and president, First National Bank of Chicago; T. W. Hughes, director and vice-president of Standard Oil (Indiana); Harry F. Blair, director and vice-president of Standard Oil (Indiana); Joseph K. Roberts, general manager, Research and Development, Standard Oil (Indiana); Dr. Max G. Paulus, vice-president, Manufacturing, Standard Oil (Indiana).

The photo at right shows: Thomas E. Sunderland, general counsel, Standard Oil (Indiana), relaxing with Joseph K. Roberts, general manager, Research and Development Department, Standard Oil (Indiana), as a party of Standard Oil (Indiana) and Pan-Am Southern officials approached Grand Hotel, Point Clear, Ala., aboard the yacht Pudlu.

Unrest in Eastern Area Curtailing U. S. Investment

Apprehension continues in top level circles over the state of affairs in the Middle and Far East. Although first fears that the Iranian situation would adversely affect the world oil supply have abated, there is danger that other countries in the oil belt of the East may follow Iran's lead in nationalizing their oil resources.

S. L. Lynn, chairman of the Natural Resources Department Committee, told the directors of the U. S. Chamber of Commerce that Russia probably is in the background in Iran, and that unrest fomented throughout the oil belt has cut down U. S. confidence in foreign investments.

Oil production here is sufficient, he said, with the natural gas supply ample for present needs. However pipe line construction has not kept pace with rapid demand increases, and production of essential metals has not been expedited to support production expansion.

West Europe Refining To Treble Capacity in 1952

A combined refining capacity of 1.250 million barrels a day, or three times the prewar volume, is anticipated for Western Europe for the end of 1952 by the Economic Cooperation Administration. Plants to provide sufficient lubricating oil to provide Europe's requirements will be in operation early in 1952.

Highlighting the report were the following items: Fuel authorizations to Marshall Plan countries totaled $149 million during March-June, $39 million of which was designated for coal and related fuels. A plant in Italy took honors as the largest project begun during the quarter both in terms of cost and ECA financing. A petrochemical plant sponsored by Montecatini Company, it will cost over $18 million, backed by $2.7 million ECA funds.

Warren, Texas Producer, Joins PAD as Administrator

J. Ed Warren will join the Petroleum Administration for Defense on April 1 to replace Bruce K. Brown as deputy administrator, who is resigning his duties June 1. Warren, an independent producer from Midland, Texas, was reportedly recommended by "all segments" of the petroleum industry. Brown will return to the presidency of Pan-Am Southern Corporation in New Orleans, having been on a leave of absence since November, 1950.

Refining Mid-Year Session To Feature New Processes

New refining processes will be featured at the two technical sessions scheduled for the mid-year meeting of the API Refining Division in San Francisco, May 12-15. The program committee is headed by W. M. Holaday, Socony-Vacuum, and he has already received a number of papers for these sessions. New information is still requested and offers of papers should be sent to F. W. Schumacher, Standard Oil Development Company, Linden, N. J., chairman of the subcommittee for developing programs; or to W. T. Gunn, director of API Refining Division, New York.

Healy Named Group Leader At Wood River Laboratory

Judd W. Healy, chemical engineer in the Standard Oil Company (Indiana) research laboratory at Whiting, Ind., has been promoted to group leader at the company's Wood River, Ill., laboratory.

Healy joined Standard in 1947.

Interior Program Will Cost $1 Billion—NPC Committee

The government proposed program to create an additional 1 million barrels of oil daily would cost approximately $1 billion and would require 3,231,000 tons of steel according to a report by a special committee of the National Petroleum Council to the Department of the Interior's oil and gas division. The council, making the report, specified that it did not mean to recommend the program nor to indicate that "the proposed increments are the most economincal or desirable ones."

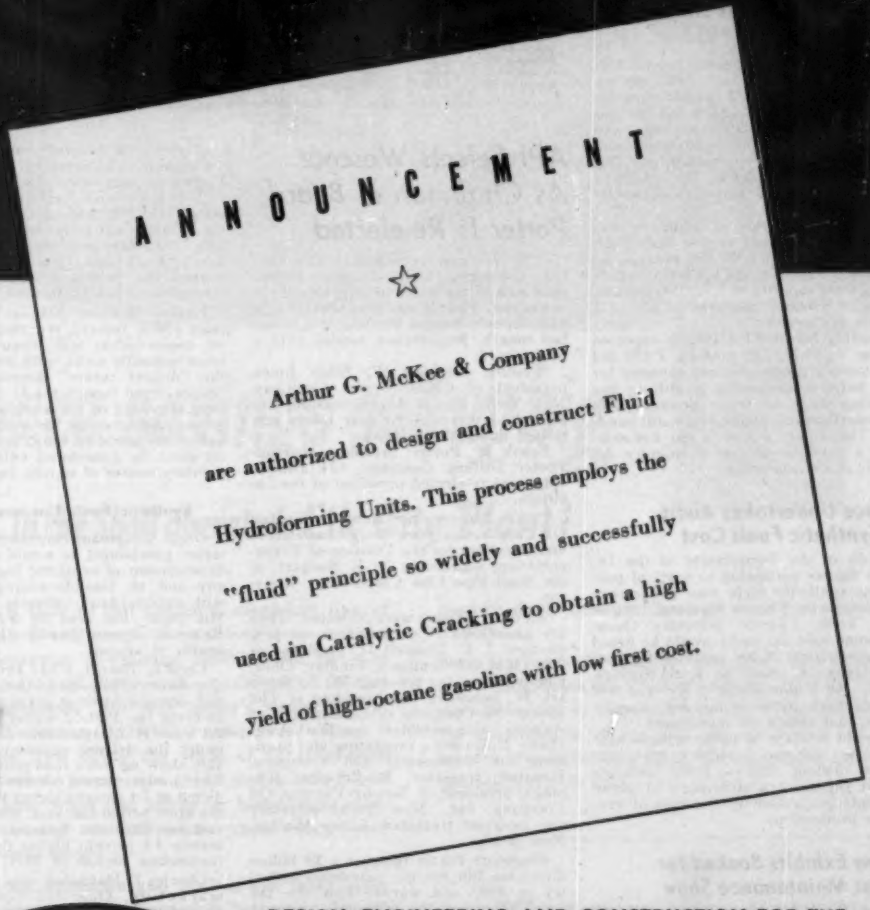
The committee noted that enough production and refining capacity already exists in reserve status to make an additional 500,000 barrels available daily, providing additional transportation and storage facilities were built.

Of the total, $485 million was earmarked for transportation facilities, $428 million for new refining facilities, and $52 million for storage facilities. The program, inclusive of production, would require 3,231,000 tons of steel.

"Given a favorable economic climate, the industry will and should continue to expand in the future as in the past," read a section of the Council committee report, "based on individual decisions of many different companies using their own funds."

As a result the government asked for estimates on new transportation and storage facilities to permit year-around utilization of 500,000 barrels daily of the existing reserve producing and refining capacity. In addition it required an additional 300,000 barrels daily of

Fluid Hydroforming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new production, along with transportation and refining facilities, in the Southwest; an additional 100,000 barrels of new production in Alberta, Canada, with new refining facilities in the Pacific Northwest. The modified plan also called for 100,000 barrels of new production in Venezuela, along with new refineries on the east coast of the U. S. and adequate transportation.

The committee's cost estimate for the latter program was stated at $965 million for refining, storage and transportation facilities only. Reliable estimates on new development and production were avoided because of the uncertainty of such enterprise.

PAD Sees Sufficient Lube Additive Supply in 1952

The Petroleum Administration for Defense has predicted there will be no shortage of lubricating oil additives for essential requirements, provided "no unforeseen circumstances" develop, and plant expansion in the construction and planning stages is not interrupted. The statements were based on the results of a survey made of additives manufacturers last April.

In 1950 production of additives was 4,204,345 pounds per month with plant capacity placed at 6,385,894 pounds. In 1951 the production was 6,320,658 pounds with a total capacity of 7,710,000 pounds, and with demand tabulated at 8,535,378 pounds per month.

Monthly demand for 1952 is expected to rise to 15,173,240 pounds. PAD did not estimate production and capacity for 1952 because expansion is still in the planning stage on many projects with tax amortizations applications still pending. The report stated it did not consider a possible increase in military demands in its conclusion.

Ebasco Undertakes Audit Of Synthetic Fuels Cost

Audit of the Department of the Interior figures pertaining to costs of produring synthetic fuels was undertaken last month by Ebasco Services, Inc., of New York. Interior Secretary Oscar Chapman said the audit would be based on hypothetical 30,000 barrel-a-day coal hydrogenation plants at Rock Springs, Wyo., and Union County, Ky. and will include such items as housing, maintenance, and return on investment.

Members of the oil industry have been perturbed by the Interior's cost estimates, feeling that a truer estimate would represent a difference of about 20 cents per gallon to the cost of synthetic production.

Many Exhibits Booked for Plant Maintenance Show

The Plant Maintenance Show to be held at Convention Hall in Philadelphia, January 14-17, 1952, will have exhibit areas from at least 156 companies, Clapp & Poliak, Inc., exposition managers, have announced. The Plant Maintenance Conference will be held concurrently with the exhibit. L. C. Morrow, consulting editor of *Factory Management and Maintenance*, will serve as chairman.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1950:									
January 28	4,956	5,470	248,411	18,263	124,270	7,202	66,337	8,380	57,036
February 25	5,000	5,377	245,586	17,708	123,589	6,990	56,056	7,855	48,662
March 25	4,848	5,469	244,227	17,239	133,406	6,870	40,577	8,171	42,546
April 29	5,014	5,314	244,744	18,038	128,655	6,531	36,686	7,372	39,260
May 27	5,116	5,591	240,842	18,704	122,757	7,201	40,607	7,421	39,308
June 24	5,365	5,636	240,762	19,626	115,036	6,968	50,589	7,461	41,291
July 29	5,522	5,879	240,226	19,961	109,076	7,268	61,437	7,570	42,253
August 26	5,699	6,197	236,054	20,268	105,796	7,550	65,841	8,543	41,697
September 30	5,928	6,051	241,631	19,524	106,383	8,480	76,734	8,306	42,330
October 28	5,895	6,051	244,805	19,878	105,062	8,259	84,057	8,449	44,310
November 25	5,886	6,238	244,497	19,847	106,434	8,591	95,768	8,470	45,566
December 23	5,763	6,159	250,709	20,075	112,631	9,439	73,273	8,715	39,914
1951:									
January 27	6,066	6,483	244,230	21,106	126,261	9,854	58,997	9,905	40,270
February 24	5,954	6,534	237,204	20,816	136,870	10,545	45,764	9,471	38,998
March 31	6,041	6,581	235,956	20,390	142,180	9,365	43,170	9,147	37,282
April 28	6,154	6,236	242,479	19,876	137,474	8,061	43,850	8,747	36,080
May 26	6,163	6,430	246,400	21,102	130,819	8,580	51,344	9,045	37,365
June 30	6,181	6,895	247,299	21,666	126,844	8,542	58,709	9,036	41,097
July 28	6,306	6,396	251,203	21,839	131,156	8,174	76,935	8,858	44,987
August 25	6,220	6,500	252,257	21,502	118,934	8,781	88,543	8,763	46,783
September 29	6,302	6,568	253,510	21,066	113,336	9,124	97,019	8,332	47,569
October 27	6,340	6,461	259,852	22,364	111,120	9,380	102,106	8,433	49,168
November 24	6,232	6,757	260,465	22,181	111,698	9,428	98,986	9,305	47,501

API Selects Wescoat As Chairman of Board; Porter Is Re-elected

L. S. Wescoat, president of The Pure Oil Company, Chicago, was elected chairman of the board of directors of the American Petroleum Institute at the association's Annual Meeting in Chicago last month. Registration totaled 5615, a new record.

Wescoat succeeds W. Alton Jones, president of Cities Service Company, New York, who is now completing the second of the two one-year terms permitted under the by-laws.

Frank M. Porter, president of Fain-Porter Drilling Company, Oklahoma City, was re-elected president of the Institute.

P. C. Spencer, president of Sinclair Oil Corporation, New York, was elected vice president for the Division of Transportation, succeeding T. E. Swigart, of the Shell Pipe Line Corporation, Houston.

All other officers were reelected: They are as follows: Vice president for production: J. C. Donnell II, president of The Ohio Oil Company, Findlay, Ohio; vice president for refining: W. L. Stewart, Jr., executive vice president of The Union Oil Company of California, Los Angeles; vice president for marketing: Harry J. Kennedy, marketing vice president for Continental Oil Company, Houston; treasurer: B. Brewster Jennings, president of Socony-Vacuum Oil Company, Inc., New York; secretary and assistant treasurer: Lacey Walker, New York.

President Porter forecast a $2 billion direct-tax bill for the petroleum industry in 1952 and warned that the tax trend threatens the industry's survival. He reported that only 6.8 percent of every income dollar has been available for reinvestment, forcing the industry into the money market to meet its capital requirements.

Lt. General Ernest O. Thompson, Texas Railroad Commissioner, condemned commercial synthetic fuel projects when he departed from his prepared text, delivered in acceptance of the API distinguished achievement gold medal. Recovery techniques alone can supply 75 billion or more barrels of oil in deserted fields, Thompson said. He warned the industry not to be "seduced by subsidy," "the first step toward nationalization." "Let's steer clear of government control that lays a withering hand on inventive initiative," he said.

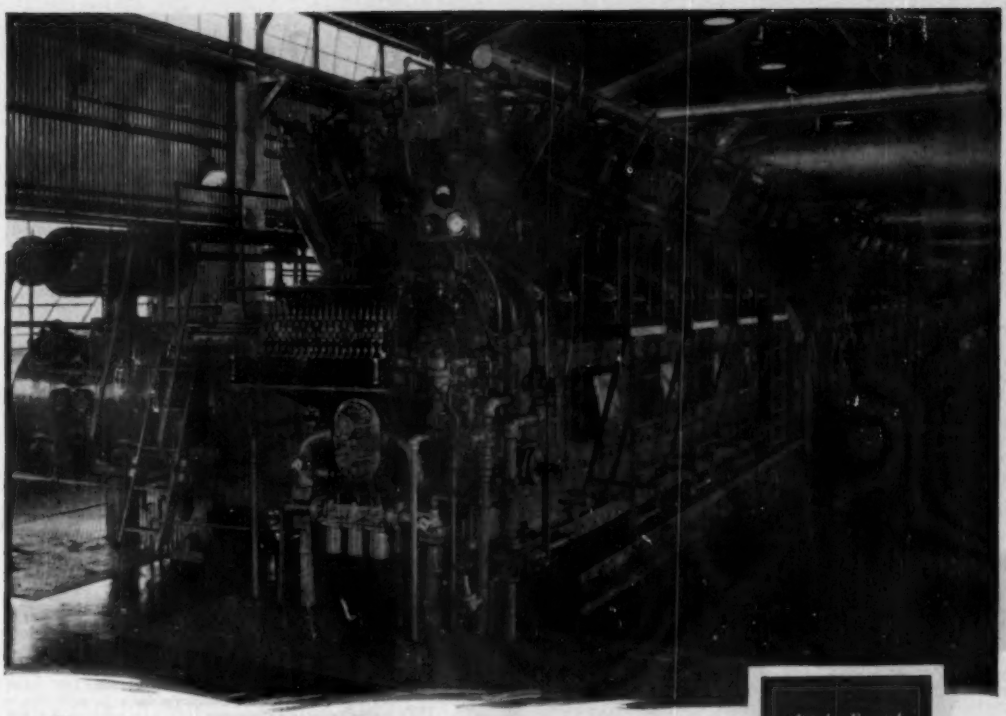
Eugene Holman, Standard Oil Company (New Jersey), reported that U. S. oil consumption will come primarily from domestic wells, with production in the "distant future" pointing to synthetics. Even though the U. S. possesses only one-third of the world's proved reserves and accounts for more than one-half of the world oil consumption, foreign oil must be considered only a supplementary source of supply, he stated.

Synthetic Fuels Encouragement

Oscar Chapman, Secretary of the Interior, proclaimed he would advance the development of synthetic liquid fuels by any and all feasible means consistent with national laws, interests, and policy. His paper was read by PAD Deputy Bruce K. Brown because Chapman was unable to attend.

Cecil L. Burrill, PAD Program Division director, in presenting the oil supply and demand forecast prepared by PAD to cover the 1951-52 winter months and the year 1952, stated that demand, even under the defense economy, will probably show no more than normal growth. The winter season demand was predicted at 7.4 percent higher than demand the same period last year, while the forecast for 1952 was forecast as approximately 4.4 percent higher than the corresponding period of 1951.

Charles Z. Hardwick, vice president of marketing, Ohio Oil Company, was elected national chairman of the OIIC, succeeding John C. Dupree. A record budget was adopted for 1952 by OIIC. Vice chairmen are: Stanton K. Smith, Smith Oil & Refining Company, Rockford, Ill.; Ralph Carey, Shell Oil, Boston; Stewart Brown, Standard Oil of California, San Francisco; W. N. Finnegan, Jr., Humble Oil & Refining Company, Houston; and P. C. Humphrey,



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Another Example of Efficient Power at Lower Cost

TAKE a look at the compact, clean-cut line of engine-driven compressors shown here — seven Cooper-Bessemer 10-cylinder GMV's. Not so long ago the rating of these units would have totaled 7,000 horsepower. But with today's *supercharged* GMV's, it adds up to 9,450 horsepower. Thus, 7 GMV's are now doing the work of 10 older-type units . . . *with no increase in speed* and in only 7-unit space. Think what this saves in installation cost, piping, housing, maintenance, supervision and other expense items!

What's more, supercharged GMV's, like these, also offer important new economies in fuel and lube oil consumption. Straight through it's a more *efficient* operation.

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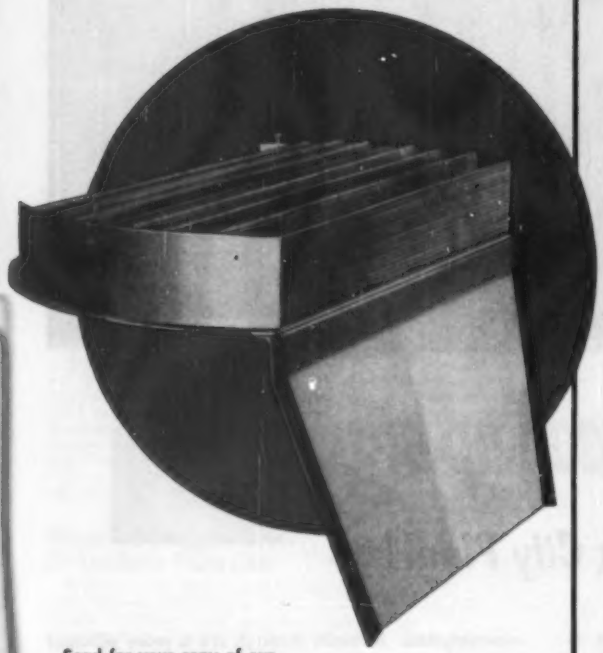

Send for your copy of our new bulletin No. 629 which gives complete information on the new "Venturi" type Kaskade tray.

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*Continental Oil Company
Daugherty Refinery
*Derby Oil Company
Dow Chemical Company
*El Dorado Refining Company
*Ford, Bacon & Davis, Inc.
Gas Machinery Company
Globe Oil & Refining Company
*B. F. Goodrich Chemical Company
Hope Natural Gas Company
International Paper Company
*Jefferson Chemical Company, Inc.
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Plains Natural Gas Company
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*Rock Island Oil & Refining Company
*Rock Island Refining Corporation
*Roosevelt Oil Corporation
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*Skelly Oil Company
*Socony-Vacuum Oil Company
South Carolina Electric & Gas Company
*Southwestern Oil & Refining Company
*Stanolind Oil & Gas Company
*Spencer Chemical Company
Sunray Oil Corporation
*The Texas Company
*Texas Natural Gasoline Corporation
Union Carbide and Carbon Corporation
*Warren Petroleum Company
*Wood River Oil & Refining Company

FOREIGN INSTALLATIONS

ICIP, Italy
*RFPA, Paris, France
*Anglo Iranian Oil Company
The Bahrein Petroleum Company, Ltd.
*Ruhrchemie, Oberhausen, Germany
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Messrs A. F. Craig & Co., Ltd.
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The Texas Company, New York.

It was announced that the 1952 API sessions would be held in Chicago November 10-13.

A panel-type symposium on evaporation loss is scheduled for this meeting, plans calling for review of published material, analysis of losses from conventional type tankage, and review of available information on conservation type tankage. It will be presented by the Technical Service Department of the API.

The Central Committee on Accident Prevention and the Central Committee on Fire Protection recommended that their chairmen continue in office another year. Both will hold mid-year meetings in Fort Worth concurrently with the meeting of the Pipe Line Technology Group, Division of Transportation during the week of April 21.

"Safety minute man" speakers which Division of Refining adopted last May, will be used again in the division's mid-year meeting in San Francisco, May 12-15.

Need for development of a refinery flare that will meet present day requirements was expressed by Dr. R. N. Giles, Standard (Ind.), as head of the committee on disposal of Refinery Wastes.

California Refinery Gets Tower Built for Russia

Once earmarked for Russia, a distillation tower has been incorporated into the refinery improvement program launched by General Petroleum Company at Torrance, Calif., to increase production of aviation fuel components. PAD has approved $528,000 at 90 percent for rapid tax amortization with $47,000 certified at 50 percent.

J. B. Gill Company will erect the facilities which are scheduled for use June, 1952.

The distillation tower was built during the war as a segment of an aviation gasoline refining plant to be shipped to the U.S.S.R. under Lend-Lease aid.

Quaker Oats Opens New Furfural Plant at Omaha

At Omaha, Nebr., a new furfural plant owned by The Quaker Oats Company is in operation using corncobs and other agricultural residues from the farms of the middle west as raw materials. The Omaha operation will make increased quantities of furfural available to petroleum refiners for the processing of lube stocks, gas-oil and catalytic cracker recycle stock.

Quaker anticipates supplying initial charges for the two new French lube oil plants soon to be on stream, as well as several plants in the U. S. whose facilities are being enlarged.

Truman Appoints Forbes Bureau of Mines Chief

President Truman has appointed John J. Forbes to succeed Dr. James Boyd as director of the Bureau of Mines. It is expected the Senate will confirm the appointment without trouble, in contrast to the 1947 scene when John L. Lewis led the fight opposing Boyd's appointment. Forbes, a graduate mining engineer of Pennsylvania State College, has served with the Bureau 37 years and has been chief of its Health and Safety division since 1948.

Cities Service Reorganizes Company Executive Staff

Cities Service Oil Company of Delaware has reorganized the executive staff to expedite its expansion program and has created three new vice presidencies to carry the extra financial, manufacturing and production loads.

Lee N. Haugen, manager of the refining division, Frank M. Perry, manager of the gasoline-chemical division, and Gentry Lee, general counsel, have been named to the new vice presidency posts.

Direction of oil production and land and geological divisions will be handled by Vice President Robert L. Kidd, with Ray Althouse as assistant. Kidd also was named president of American Gas Production Corporation, a subsidiary.

C. S. Mitchell was elected president of Cities Service Pipe Line Company, and Vice President Sam Harlan was elected president of American Gas Production Corporation. Vice President T. P. Steeper was elected president of Terminal Facilities, Inc.

NPC Reports Synthetic Fuel Costs 43 Cents Per Gallon

Synthetic gasoline from coal hydrogenation would cost 43.5 cents per gallon according to a report submitted by the Synthetic Liquid Fuels Production Costs committee of the National Petroleum Council. The figure is based on operating plants with a total capacity of 216,000 barrels daily, and does not include the cost of distribution, marketing or sales tax. On the same basis, a gallon of gasoline from oil shale would cost 14.7 cents delivered to a major consuming area.

A six percent return is employed in developing the gasoline cost, and the committee felt that it would be hard to attract capital to a speculative venture that showed less than 15 percent return on total capital.

THE OIL MAN'S CALENDAR

DEC. 26-31	American Assn. for the Advancement of Science, Annual, Philadelphia, The Bellvue-Stratford.
JAN. 1952 14-17	Plant Maintenance Show, Philadelphia, Convention Hall.
14-18	Society of Automotive Engineers, Inc., Annual, Detroit, Hotel Book-Cadillac.
MAR. 3- 7	ASTM, Spring and Committee Meeting, Cleveland, Ohio, Hotel Statler.
8-10	Southwestern Gas Measurement Course, U. of Oklahoma, Norman.
10-14	Natl. Assn. of Corrosion Engineers, Annual Conference and Exhibition, Galveston, Galvez Hotel.
16-19	AIChE, Regional, Atlanta, Biltmore Hotel.
31 to Apr. 2	WPRA, 40 Annual, San Antonio, The Plaza Hotel.
APRIL 16-18	National Petroleum Association, Semi-Annual, Cleveland, Hotel Cleveland.
30 to May 2	Natural Gasoline Association of America, Annual, Houston, Rice Hotel.
MAY 11-14	AIChE, Regional, French Lick, Ind., French Lick Springs Hotel.
12-15	API, Div. of Ref. Midyear, San Francisco, St. Francis Hotel.
12-15	LPGA, Annual, Chicago, Palmer House.
26-28	AGA, Production and Chemical Conf., New York, Hotel New Yorker.
JUNE 23-27	ASTM, Annual, New York, Hotel Statler.
OCT. Wk. of Oct. 20	AGA, Annual, Atlantic City, City Auditorium.
20-24	National Safety Council, National, Chicago, Stevens Hotel.

Marketing Firm Purchases New Jersey Refining Plant

Purchase of Ultra-Penn Refining Company is only one development in the planned expansion of the Borne, Scrymser Company of Elizabeth, N. J., according to William L. Less, president. Borne, Scrymser is a marketing company of lubricating and technical oils and specialty greases.

Ultra-Penn Refining was chartered in 1931, succeeding Butler County Oil Refining Company which in turn had succeeded High Grade Oil Company. It had been in the business of refining and marketing lubricating oils, technical naphthas, furnace oils, kerosene, gasoline, and others.

Berg Heads OIIC Group Kansas-Oklahoma District

Harold R. Berg, Tulsa regional manager for Ethyl Corporation, has been named to head the Kansas-Oklahoma district OIIC during 1952-53. He succeeds Harry Trower, former vice president of Phillips Petroleum Company, who has served as district chairman since April, 1949.

J. B. Smith, Wichita, vice president of The Vickers Petroleum Company, will continue as vice chairman of the two-state organization.

Big Plans Being Made for 1952 Instrument Conference

The National Instrument Conference and Exhibit to be held in Cleveland, September 8-12, 1952 will be the largest and most comprehensive meeting ever held by the Instrument Society of America, according to Richard Rimback, exhibit manager.

Floor plans and details on the show have just been mailed from ISA headquarters, 921 Ridge Avenue, Pittsburgh 12, Pa., to several hundred companies which have a priority on the choice of

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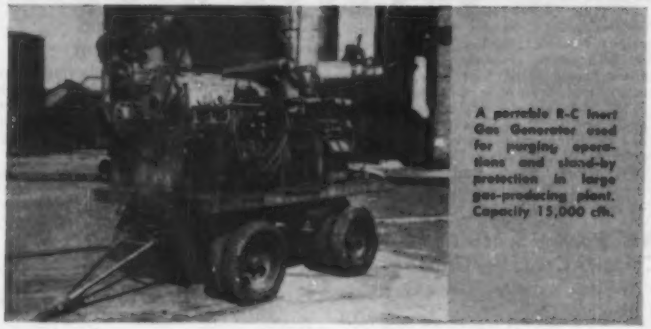

A portable R-C Inert Gas Generator used for purging operations and stand-by protection in large gas-producing plant. Capacity 15,000 cfh.

Today's urgent production demands can tolerate no unwarranted risk of interruption by explosions which might cause even small fires or other plant damage. Against such hazards, R-C Inert Gas Generators provide positive, economical protection.

This protection is essential in plants where inflammable gases, liquids, explosive dusts and other dangerous materials are handled, processed or stored. Available either in stationary or mobile units, R-C Inert Gas Generators greatly reduce the risks from fires caused by explosions. They are compact, simple and sturdy in construction and operate at extremely low cost. Available in capacities from 1,000 to 35,000 cfh.

If your operations involve materials or processes which might cause explosion-produced fires, investigate the protection afforded by R-C Inert Gas Generators. Installation costs in many cases can be offset by insurance savings. Ask us for details.

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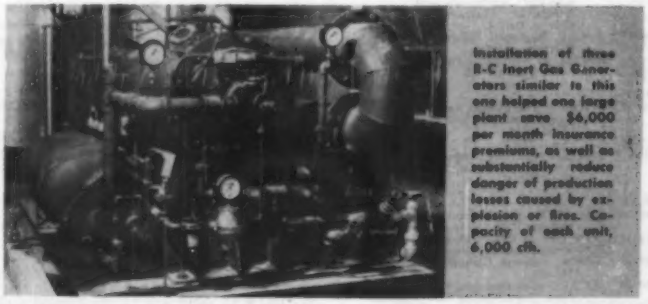


Installation of three R-C Inert Gas Generators similar to this one helped one large plant save $6,000 per month insurance premiums, as well as substantially reduce danger of production losses caused by explosion or fires. Capacity of each unit, 6,000 cfh.

ROOTS-CONNERSVILLE
BLOWER BUILDERS SINCE 1854
ONE OF THE DRESSER INDUSTRIES

The MONTH...

space due to exhibiting at previous shows.

Mailings to other companies, which have expressed an interest in the forthcoming exhibit will be sent out at expiration of the priority period.

Szekely Nominated for 1952 ASH & VE Presidency Slate

Members of the American Society of Heating and Ventilating Engineers will receive a slate of the following nominees for 1952 office to be voted on by mail ballot.

Ernest Szekely, president of the Bayley Blower Company of Milwaukee, president; Reg F. Taylor, consulting engineer of Houston, first vice president; L. N. Hunter, vice president of research for National Radiator Company, second vice president; J. Donald Kroeker, consulting engineer, Portland, Ore., treasurer.

The results will be announced at the society's 58th annual meeting in St. Louis, January, 1952.

Szekely, vice president for 1951, was born in Hungary and graduated from the University of Budapest with a degree in mechanical engineering. Before coming to the U. S. he taught at the University. In 1912 he joined the Guarantee Construction Company of New York, and since that time has become president of Bayley Blower Company.

World's First Gas Turbine Merchant Ship in Service

The world's first gas-turbine powered merchant ship, the 12,000-ton tanker Auris, has been put into regular service by Shell Oil Company. The Auris recently completed successful sea trials on a voyage to the Caribbean.

Considered one of the most important recent developments in the shipping field, the tanker's new type engine offers several clear advantages. The gas turbine has only two moving parts, instead of the dozens in conventional engines. It is many tons lighter and requires considerably less space than ordinary engines of the same power. Also, the risk of failure as well as the cost of operation and maintenance are lower, officials said.

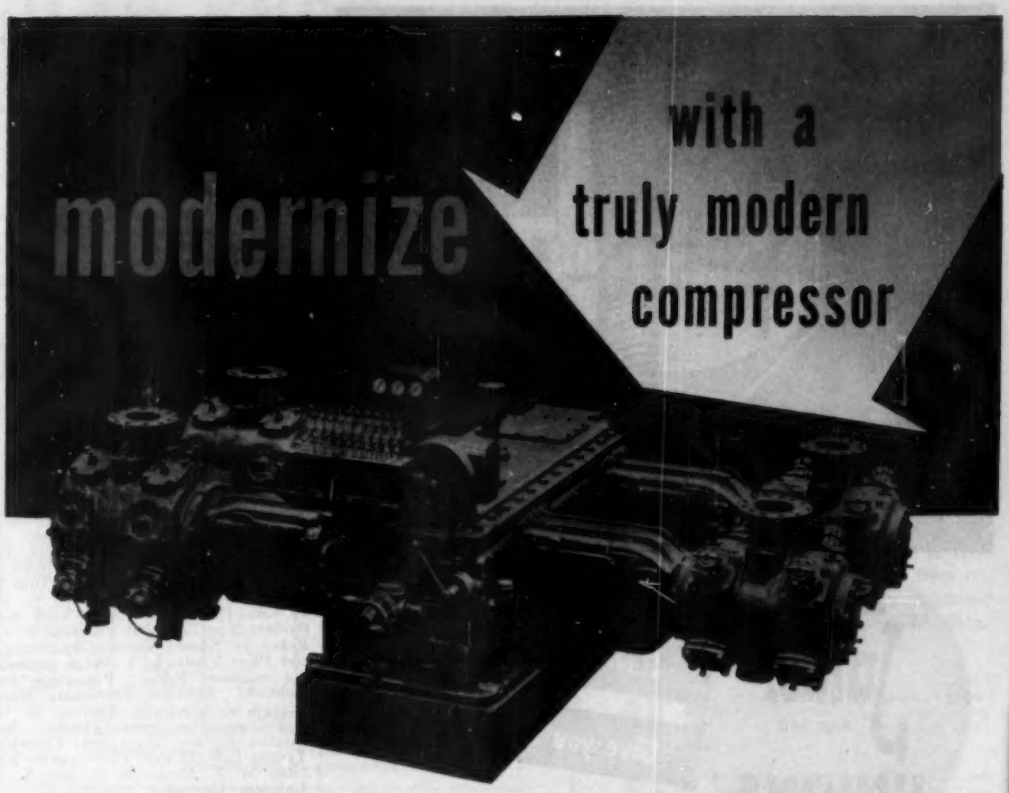
DPA Grants $55 Million for Pilot Shale-Oil Project

The Department of Interior has been granted a $55 million loan to erect and operate a shale-oil plant because of backing by the Defense Production Administration's Petroleum Branch of Industrial Resources Division. However the PBIRD specified that it would be preferable to have private industry set up and operate necessary demonstration shale-oil projects.

Stanolind On-Job Study Graduates 27 Employes

Under Stanolind Oil and Gas Company's "back-to-school" program, 27 Stanolind engineers recently graduated from an on-the-job-training program. The course is aimed at keeping technical personnel currently abreast of new developments within the field. James F. Pollock, senior process engineer and a

modernize with a truly modern compressor



For your air compressor requirements in the 150-4500 bhp range, no compressor today . . . *no compressor in history* . . . can match the distinct advantages of the Clark Balanced/Opposed, Motor-Driven line.

Truly modern in every respect, it embodies only well established design principles. Thoroughly performance-proved in the toughest kinds of service, Clark Balanced/Opposed units represent the most outstanding industrial air compressor development of our times. Their features and benefits in installation, operation and maintenance are unrivaled.

Obtain *all* the facts today on the complete Clark Balanced/Opposed Compressor line available in 2, 4 and 6 cylinder sizes; 8, 14 and 17" stroke; 150-4500 bhp. Request Bulletin 118.

- *Perfect balance for vibration-free performance.*
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- *Absence of complex field alignment.*
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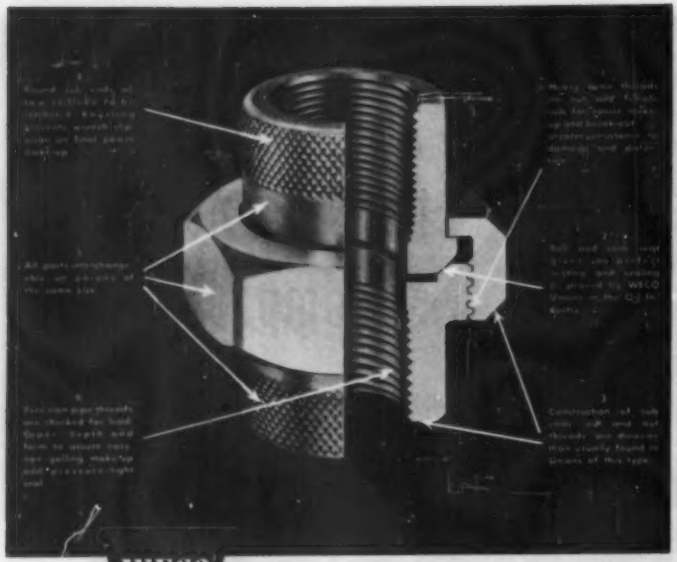


WECO "Junior" Fig. 342 UNIONS

Have more features!

Give you better service!

● Point by point, WECO "Junior" Unions give you more value through better service and longer life. Frequent make-up and break-out can't damage the Acme threads or the famous WECO metal-to-metal ball and cone seat . . . it always holds. Heavier construction assures repeated use without distortion of sub-ends or nut . . . without damage to sub-end pipe threads.

Keep WECO "Juniors" in stock in the convenient cartons of 12 and 24 unions. Ask your Supply Store or WECO representative for WECO "Juniors".

3000 lb.
Non-Shock C.W.P.
All-Steel
Sizes:
⅛" through 2"

CONVENIENTLY CARTONED:
Sizes ⅛", ¼", ⅜", ½", ¾" and 1" packed 24 to carton; 1¼", 1½" and 2" packed 12 to carton.

WECO

WELL EQUIPMENT MFG. CORP.

HOUSTON 1, TEXAS

CHIKSAN COMPANY

Bres. Calif. Chicago 3, Ill. Newark 2, N. J.

Export Sales: CHIKSAN EXPORT COMPANY Bres. Calif. Newark 2, N. J.

The MONTH...

Stanolind employe since 1946, directed the process engineering studies. The students were gathered from division and district offices in five states.

ASTM Appoints Committees For Convention Next June

A general committee on arrangements has been appointed for the Fiftieth Anniversary Meeting of the American Society for Testing Materials to be held in New York, June 23-27. J. R. Townsend, materials engineer of the Bell Telephone Laboratories will head this committee.

Officers and subcommittee chairmen of the general committee are as follows:

Honorary chairman, F. M. Farmer, Electrical Testing Laboratories; Chairman, J. R. Townsend, Bell Telephone Laboratories; Vice Chairmen, H. C. R. Carlson, design consultant, N.Y.C., and L. T. Work, consulting engineer, N.Y.C.; Secretary G. O. Hiers, National Lead Company; Assistant Secretary, W. B. Anderson, Titanium Pigment Corporation; Treasurer, Jerome Strauss, Vanadium Corporation of America.

Subcommittee chairmen: Dinner, H. C. R. Carlson, design consultant, N.Y.C.; Entertainment, Sam Tour, Sam Tour & Company; Information Center, E. P. Pitman, The Port of New York Authority; Non-Technical Program, L. C. Beard, Jr., Socony-Vacuum; Laboratory and Plant Visits, L. T. Work, consulting engineer, N.Y.C.; Promotion and Publicity, Ephraim Freedman, Macy Bureau of Standards; Finance, K. G. Mackenzie, The Texas Company; Apparatus, Gordon Thompson, Electrical Testing Laboratories; Photographic Exhibit, M. P. Davis, N. Y. and N. J. Lubricant Company.

Noted Researcher to Assist National Science Foundation

Dr. Paul E. Klopsteg, professor of applied science and director of research of Northwestern Institute of Technology, has been appointed assistant director of the National Science Foundation for the Division of Physical, Mathematical and Engineering Sciences. His work concerns research support. Internationally known as a research administrator, his services have been used by the American government, and more recently in Lahore, Pakistan, where he advised on scientific and technical education of Pakistan at all levels.

Fleischmann Heads Speakers At Plant Maintenance Show

Manly Fleischmann, administrator of the Defense Production Administration, will head a group of 56 speakers in an extensive discussion of plant maintenance problems when the Plant Maintenance Conference convenes at Convention Hall, Philadelphia, Jan. 14-17, 1952.

It is sponsored by the American Society of Mechanical Engineers and the Society for the Advancement of Management. The American Society of Lubrication Engineers conducts the panel on lubrication.

The conference, which will be held in conjunction with the Plant Maintenance Show, has as its general chairman, L. C. Morrow, consulting editor

BLAW-KNOX *Announces...*

new tailor-made high capacity natural gas dehydration plants

OPERATING CONDITIONS

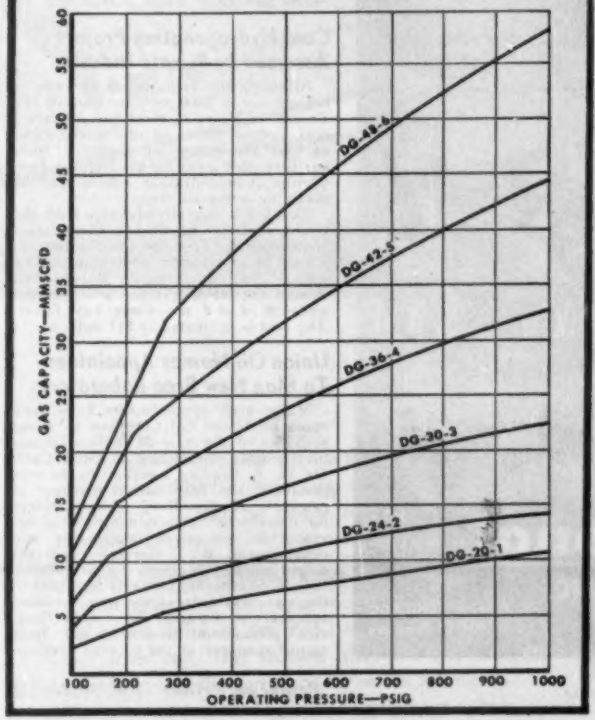
Gas Capacity at 500# and 1000# Operating Pressures for Blaw-Knox Standard Glycol Dehydration Units

Model No.	Max. Gas Capacity MMSCFD	Inlet Gas Temp. °F	Inlet Gas Press. PSIG	Dew Point Depression °F	Pressure Drop Thru Unit PSI
DG-20-1	7.3	80°	500	50°	3
DG-24-2	10.5	80°	500	50°	3
DG-30-3	16.6	80°	500	50°	3
DG-36-4	23.7	80°	500	50°	3
DG-42-5	32.0	80°	500	50°	3
DG-48-6	42.0	80°	500	50°	3
DG-20-1	10.5	80°	1000	50°	3
DG-24-2	14.5	80°	1000	50°	3
DG-30-3	22.7	80°	1000	50°	3
DG-36-4	32.5	80°	1000	50°	3
DG-42-5	44.7	80°	1000	50°	3
DG-48-6	58.0	80°	1000	50°	3

GAS CAPACITY OF BLAW-KNOX STANDARD GLYCOL DEHYDRATION UNITS VS. OPERATING PRESSURE IN PSIG

Inlet Gas Temp. 80°F Guaranteed Depression 50°F

Pressure Drop Thru Unit 3 PSI



Blaw-Knox now offers a line of natural gas dehydration plants that benefit from the economics and proved efficiencies in operation obtained by standard design, but which are flexible enough to meet the exact requirements of each customer's needs.

Check the adjoining table and chart for operating characteristics of the various models against your own requirements. A Blaw-Knox engineer will be glad to give you further data.

Blaw-Knox plants are . . .

1. Tailor-made to fit your exact requirements based on a standard process and the use of standard parts and subassemblies.
2. Blaw-Knox high capacity natural gas dehydration plants are flexible because they are skid-mounted, prefabricated and assembled.
3. All Blaw-Knox high capacity natural gas dehydration plants are accessible, can readily be disassembled for maintenance. Individual components are interchangeable and the design features inherent flexibility.
4. Guaranteed to meet performance specifications which are based on actual field and engineering calculations.
5. Reliable. These units have long life and require a minimum of maintenance. Ask any of the Blaw-Knox satisfied customers.

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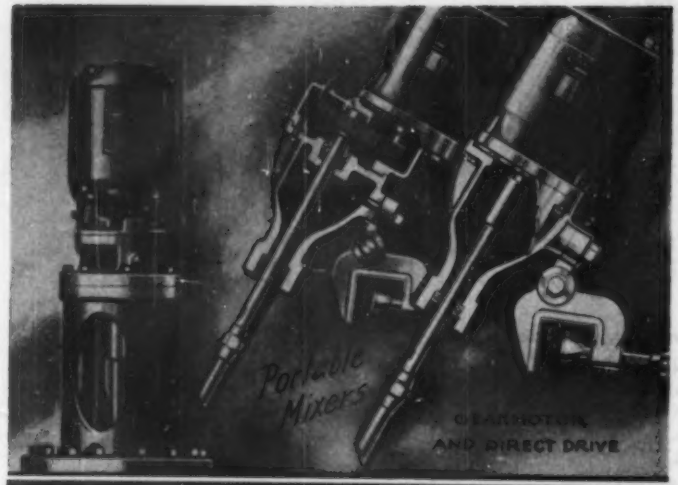
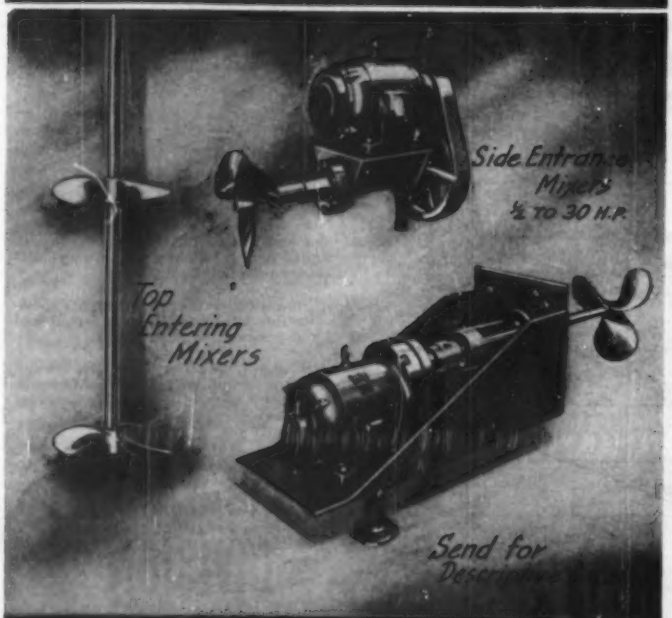


International
Precision-made MIXERS



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The MONTH . . .

of "Factory Management & Maintenance." More than 14,000 are expected to attend the conference and 225 companies are expected to exhibit at the show, which will emphasize preventive maintenance to help meet the huge military and civilian production schedules of next year.

Highlight of the conference will be the division into more than 30 separate sessions in order to accommodate special talks on individual industry needs and to permit executives to discuss problems that arise in plants of varying sizes and varying maintenance needs.

Dr. Frey Heads Chemical Division of ACS for 1952

Dr. Frederick E. Frey, assistant director of research of the Phillips Petroleum Company, Bartlesville Okla., has been elected chairman of the American Chemical Society's Division of Petroleum Chemistry for 1952. He succeeds Dr. Bernard H. Shoemaker, assistant director of research of the Standard Oil Company of Indiana, Whiting, Ind.

A. L. Lyman, director of the Richmond, Calif., laboratories of the California Research Corporation, was chosen chairman-elect, and Dr. Warren F. Faragher, technical adviser to the vice-president in charge of research, Houdry Process Corporation, Marcus Hook, Pa., was named secretary-treasurer.

Dr. Frey graduated from the College of Wooster and also received the M. S. degree from Ohio State University in 1924 and the honorary Sc. D. degree from Wooster in 1948. Before joining the Phillips research division in 1927, Dr. Frey was a chemist for the United States Bureau of Mines, Pittsburgh.

Coal Hydrogenation Project Assumed by Private Industry

Although the Department of Interior request for a $400 million loan to the Bureau of Mines to erect and operate a coal hydrogenation plant for the commercial production of synthetic fuels has been filed away by the Defense Production Administration, action will be taken by a private firm.

The DPA has already approved the Union Carbide and Carbon Corporation application for fast tax amortization on a coal hydrogenation pilot plant which will be built at Institute, W. Va. Although the DPA specified a 50 percent write-off it did not name any figure. The cost is estimated at $11 million.

Union Oil Names Appointees To Man New Brea Laboratory

Major staff appointments have been made by Union Oil Company to direct activities of the new $8 million laboratory nearing completion at Brea, Calif. Dr. W. E. Bradley, assistant to the vice president, has been named manager of research. Homer Reed, chief engineer for manufacturing, was named chief engineer in charge of engineering and development. R. J. Garofalo, assistant patent counsel, becomes patent counsel.

J. E. Sherborne, formerly assistant to the vice president, is the new assistant manager of research. Dr. Clyde Berg, vice presidential assistant, has been named manager of the process develop-

for the plant you are planning for tomorrow, it will pay you to investigate now

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NON-LUBRICATED LIFT-PLUG VALVES

No matter what the service may be, here is a plug valve that fits. Featuring a removable seat and plug, it can be easily and economically trimmed in any desired corrosion-resistant alloy.

The Cameron Lift-Plug Valve requires no lubrication, either for easy operation, or obtaining a tight seal. Think of the man hours and grease it will save you. This feature also prevents contamination of line products by valve lubricants. There is nothing to clog meter equipment either.

Let us send you a booklet that tells you the complete story of this remarkable valve. Like other plant operators who use these valves in particularly difficult services, you may find them to be the answer to all of your problems too.

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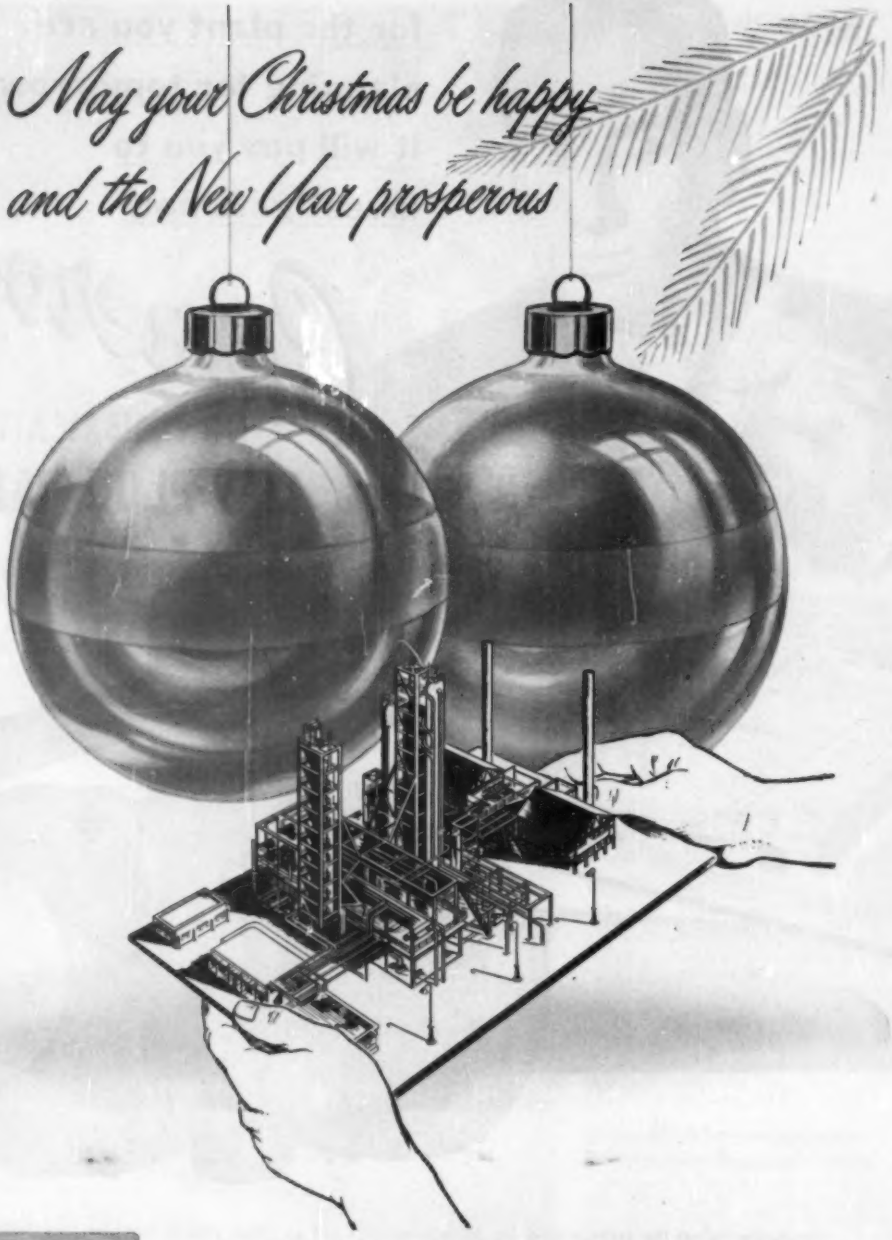
May your Christmas be happy and the New Year prosperous



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DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

The MONTH . . .

ment with headquarters at the Los Angeles refinery. Arnold Kelley was named supervisor of manufacturing processes with headquarters also in Los Angeles.

At Brea, Jack Tielrooy was named supervisor of chemical processes, and Paul Foreman, supervisor of process economics.

ACS Gas and Fuel Chemistry Committeemen Are Announced

Newly appointed committeemen for the American Chemical Society's division of gas and fuel chemistry for 1952 were announced recently. Dr. John F. Foster, supervisor of fuels research at the Battelle Memorial Institute, Columbus, Ohio, has been elected chairman. The chairman-elect is George D. Creelman, research director of the M. A. Hanna Company of Cleveland. Dr. Harlan W. Nelson, also a supervisor of fuels research at the Battelle Memorial Institute, was named secretary-treasurer.

Before joining the Battelle staff in 1943, Dr. Foster, a Ph.D. graduate of Stanford University, was a research physical chemist for the General Electric Company at Pittsfield, Mass.

Arthur Little Opens Latin Office in Mexico City Area

An office has been opened in Mexico City by Arthur D. Little, Inc., Cambridge, Mass., consulting research and engineering organization. The new office will serve the company's growing number of Latin American clients and will also conduct surveys and investigations for U. S. clients interested in the rapid industrial and commercial expansion now taking place in many parts of Latin America.

The office is headed by Richard W. Plummer, who until recently was vice-president of E. R. Squibb & Sons de Mexico and in charge of the Squibb manufacturing laboratories in Mexico.

Chemical Engineering Grant Made by Chemical Company

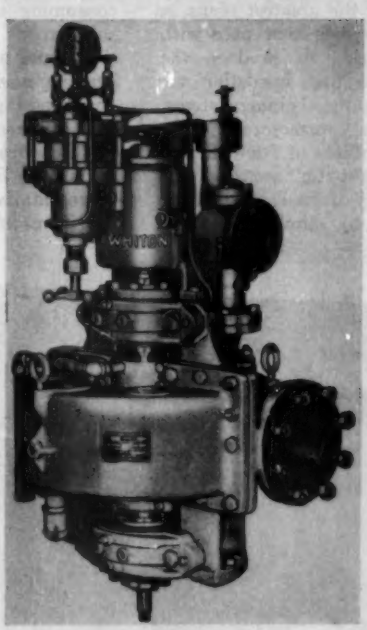
Dr. Carl C. Monrad has been appointed to hold the chair in chemical engineering established at Carnegie Institute of Technology through a grant from the Columbia-Southern Chemical Corporation, a subsidiary of Pittsburgh Plate Glass Company. The grant is for $15,000 per year to support chemical engineering research and the salary of the professor.

Dr. Monrad joined the Carnegie faculty as an associate professor of chemical engineering in 1937 and became a full professor five years later. He was made head of his department in 1947. At present he serves as consultant to the Office of Rubber Reserve of the Reconstruction Finance Corporation in Washington, D. C.

ECA Sponsors U. S. Tour Of Foreign Oil Delegates

Sponsored by the Economic Cooperation Administration under its technical assistance program, two groups of European petroleum men spent a six-week study tour in the United States, returning to Europe early this month. The 20 visitors, representing the United King-

Whiton SOLID STEEL ROTOR
STEAM TURBINES



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Ric-wiL, for forty years the greatest name in insulated piping systems, has kept pace with every known development to produce the world's finest protection and insulation for underground or outside overhead piping systems. Alert and cost-conscious contractors and engineers realize the advantages of Ric-wiL prefabricated 21-foot "straight-run" sections.

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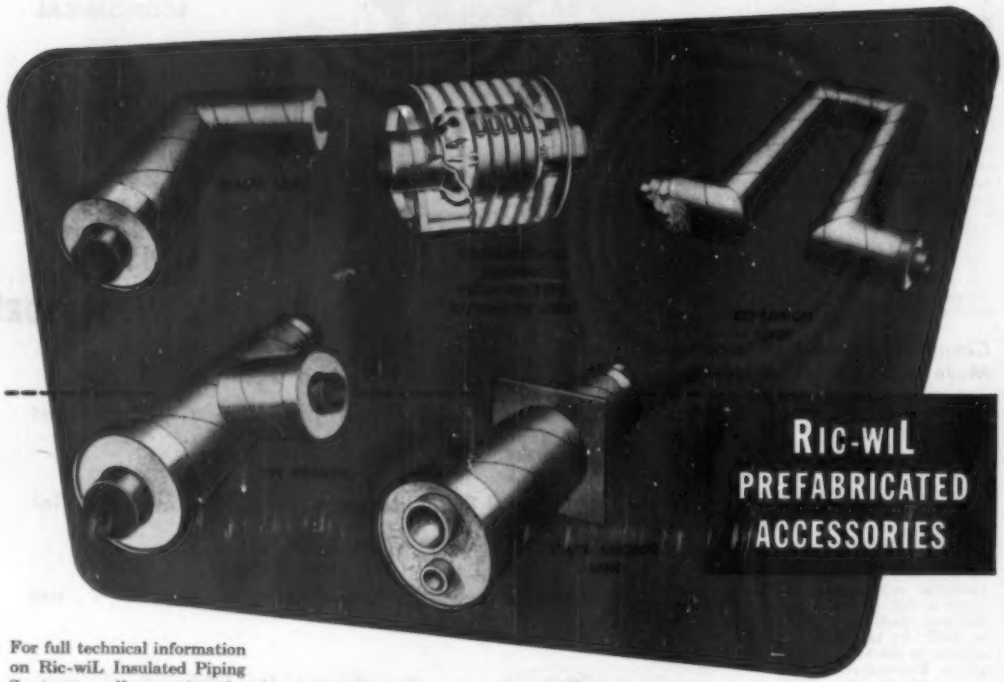
The use of the finest known materials, and exacting manufacturing standards give Ric-wiL Insulated Piping Systems "built-in" features for high efficiency performance and extremely long maintenance-free life.

Call the Ric-wiL office nearest you and our representative will be glad to discuss your specific problems at your convenience.



For full technical information on Ric-wiL Insulated Piping Systems, call or write the Ric-wiL office nearest you or Dept. 5-R in Cleveland, Ohio.

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INSULATED PIPING SYSTEMS
THE RIC-WIL COMPANY · CLEVELAND, O.
OVERHEAD UNDERGROUND

FOR FORTY YEARS THE GREATEST NAME IN INSULATED PIPING SYSTEMS

The MONTH...

dom, France, Italy, Belgium, Netherlands Germany and Austria, were divided into refining and producing study groups.

Pan-Am Destrehan Refinery Names Technical Director

Howard A. Parker, Jr., formerly of the Research Department of Standard Oil Company (Indiana) has been named technical director of Pan-Am Southern Corporation's Destrehan, La., refinery.

Parker

Parker, who was group leader in charge of process design for the Indiana company fills a key position in the Destrehan plant now being expanded at a cost of several million dollars to bring its crude-running capacity up to 30,000 barrels a day.

Parker, who holds B.S. and M.S. degrees from Cornell University, joined Standard of Indiana in April, 1944, as a process design engineer and two years later became the group leader.

Dallas Office Is Established By Merritt-Chapman & Scott

Merritt-Chapman & Scott Corporation has established an office at Dallas to serve as headquarters for the 91-year-old company's construction activities in the Southwest and Gulf Coast areas. This office, in the Kirby Building, will be headed by J. B. Allinson, who has been active in a wide field of construction operations for the past ten years, most of them in the Southwest.

Establishment of the Dallas office marks a move by Merritt-Chapman & Scott "to further operations in an area which has proved an expanding source of work in the company's fields of industrial, building, heavy and marine construction." Company headquarters are in New York.

Norman Robey to Casper

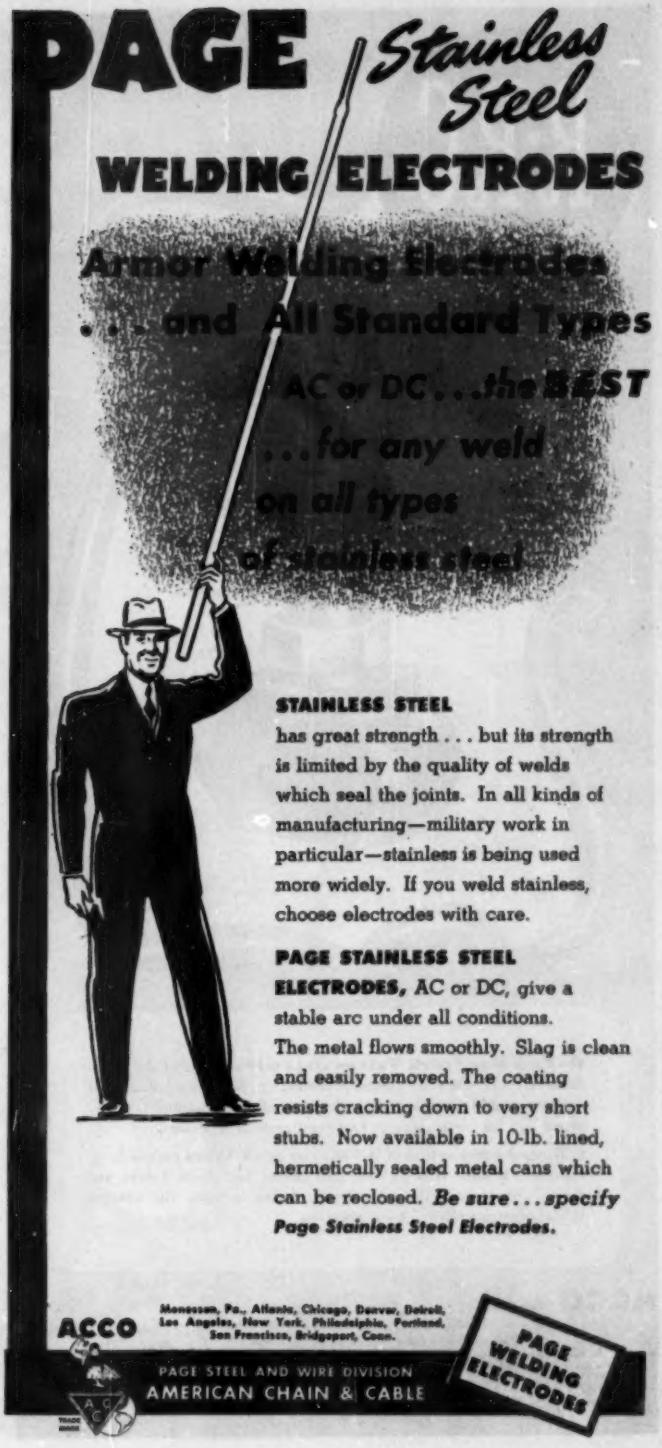
Norman T. Robey on, December 1 became an additional assistant general superintendent of the Casper, Wyo., refinery of Standard Oil Company (Indiana). He has been assistant superintendent of the heavy oils division at the company's Wood River, Ill., refinery.

Robey joined Standard in 1936 as a chemical engineer in the Whiting, Ind., research laboratory.

Pigott Installed President Of Mechanical Engineers

Reginald J. S. Pigott, director of the engineering division of Gulf Research and Development Company, Pittsburgh, a subsidiary of Gulf Oil Corporation, has been elected and installed as president of The American Society of Mechanical Engineers for 1952. The new president will succeed J. Calvin Brown, of Los Angeles.

The regional vice presidents elected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Armor Welding Electrodes
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on all types
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has great strength ... but its strength is limited by the quality of welds which seal the joints. In all kinds of manufacturing—military work in particular—stainless is being used more widely. If you weld stainless, choose electrodes with care.
PAGE STAINLESS STEEL ELECTRODES, AC or DC, give a stable arc under all conditions. The metal flows smoothly. Slag is clean and easily removed. The coating resists cracking down to very short stubs. Now available in 10-lb. lined, hermetically sealed metal cans which can be reclosed. Be sure ... specify Page Stainless Steel Electrodes.
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READING-PRATT & CADY VALVES

The MONTH . .

are: Willis F. Thompson, chief mechanical engineer, Westcott & Mapes, Inc., New Haven, Conn.; Ernest H. Hanhart, consulting mechanical engineer, Baltimore, Md.; Ernest S. Theiss, assistant chief engineer, Davey Compressor Company, Kent, Ohio, and Samuel H. Graf (reelection), director, Engineering Experimental Station, Oregon State College, Corvallis, Ore.

Elected directors-at-large were Albert C. Pasini, superintendent, production department, The Detroit Edison Company, Detroit, Mich., and Paul B. Eaton, head, mechanical engineering department, Lafayette College, Easton, Pa.

Pigott has been director of engineering research of Gulf Research & Development Company since 1929.

Dr. Maxwell Elected to ASTM To Fill Executive Vacancy

Dr. Harold L. Maxwell, supervisor of general consultants, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del., has been elected a vice president of the American Society for Testing Materials to fill a vacancy that existed in the board. He will serve as a vice president through the Society's 50th anniversary meeting in New York City, June, 1952.

Dr. Maxwell received his Ph.D. in chemical engineering and metallurgy from Iowa State College; he was instructor in Industrial Chemistry there for two years, and associate professor of Chemical Engineering, Purdue University, 1926-1930. A leading authority on materials, particularly in the field of metallurgy, Dr. Maxwell was employed as Metallurgist for the Du Pont Company for 16 years. He was appointed to his present position as supervisor of general consultants in 1946.

Faragher's War Work Cited

Dr. Warren F. Faragher, technical advisor to the vice president for research and development of Houdry Process Corporation, Philadelphia, was one of twelve industrialists from that area who received awards from the Department of the Army for their investigations and contributions to the World War II effort in the field of industrial intelligence.

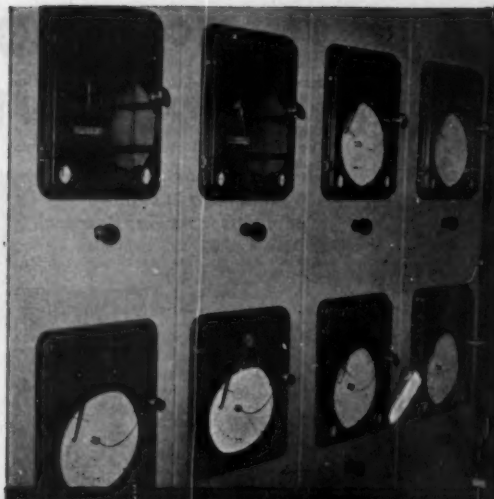
His services as an investigator of the German fuels and lubricants industry near the end of World War II were cited.

Opens Consulting Office

H. L. Barnebey, formerly sales promotion manager and Chlor-Alkali department manager for Blaw-Knox Construction Company, has established his own business in Pittsburgh to give aid in the selection, evaluation, and licensing of important chemical and petroleum processes.

Joint Army-Navy Order Specifies Synthetic Oil

Specifications for a synthetic lubricant that will operate between temperatures ranging from minus 65° to plus 500° F. have been released in order MIL-L-7808, on a joint Army-Navy basis. Base of the new lubricant is one of the class of aliphatic diesters to which phenothia-



Serving The **OIL** and **GAS** Industries

More and more refinery and pipeline engineers are specifying American Meter Company's precision equipment for *accurate, automatic control* of flow, pressure, liquid level and other continuous process variables — with *minimum maintenance.*

These installations of the East Tennessee Pipe Line Company, for the control of natural gas, are typical in the gas industry — *Reliance CBVA Control Valves,* with valve positioners, are operated by *American Meter Company Pressure Controllers.*

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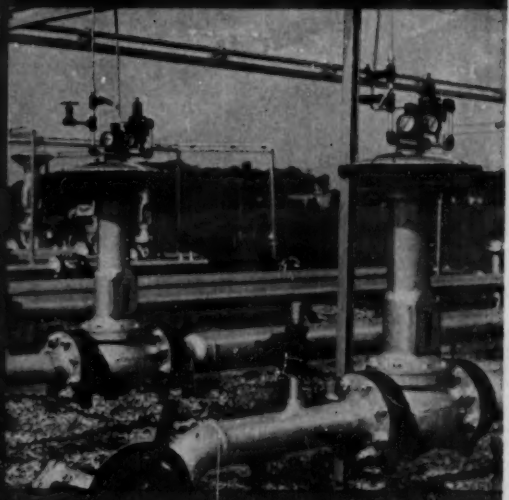
4. Orifice Meters, Integrating
5. Orifice Meters, Telemetering
6. Orifice Meters, Integrating, Remote Counter
7. Meter Runs
8. Orifice Fittings
9. Differential Valves
10. Controllers, Pressure
11. Controllers, Flow
12. Temperature and Pressure Recorders



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INSULATION FOR HIGH & LOW TEMPERATURE

The MONTH . . .

zine has been added to prevent oxidation at high temperatures, and tricresyl phosphate to prevent gear wear. Copies of the specification may be obtained from the U. S. Naval Air Station at Johnsville, Pa.

Dr. Steadman to Explore Chemicals from Gas Research

Dr. Thomas R. Steadman has resigned his position as organic chemist with the B. F. Goodrich Company to accept employment with the National Research Corporation of Cambridge, Mass. Dr. Steadman received his B.S. in chemistry from Rensselaer Polytechnic Institute in 1937, and his Ph.D. in organic chemistry from Harvard in 1941. Prior to joining Goodrich in 1940, Dr. Steadman had acted as private assistant to Professor W. M. Lauer at the University of Minnesota. At the National Reseach Corporation he will supervise the organic chemistry phases of the reasearch program concerning new chemicals from natural gas.

Steadman

U. S. Coops Handle Ten Percent of All Farm Needs

"Petroleum Operations of Farmer Cooperatives," a report by the Agricultural Department, reported that at the end of 1950 about 2230 local cooperatives were in business distributing liquid petroleum products to the nation's farms at the rate of about 1.4 billion gallons annually. Coops have 2685 bulk plants, 2000 service stations and 5660 tank trucks which aid in the distribution of about 16 percent of the total oil fuel requirements of farmers in this country.

Coops accounted for about ten percent of all lubricating oils and greases used by the agricultural population, and about 15 million gallons of LP-gas.

Standard Indiana Announces Promotions for Five Men

New changes in executive personnel were announced by Standard Oil Company (Indiana) recently. H. F. Glair, general manager of manufacturing since 1933, and a director since 1934, was appointed director of purchases. He began his career with Standard Oil as a clerk at Whiting in 1906, working intermittently while completing his schooling at the University of Illinois. He is responsible for patents covering improvements in the removal of wax from oil as well as novel improvements in the manufacture of candles.

S. A. Montgomery was advanced to general manager of manufacturing from his position as assistant. An employe since 1919, he was elected to the board last month.

Dr. W. J. McGill, superintendent of operations since 1948, was named assistant general manager. He joined the company in 1924 as a chemist at Whiting and four years later was transferred to the Wood River refinery where he ad-

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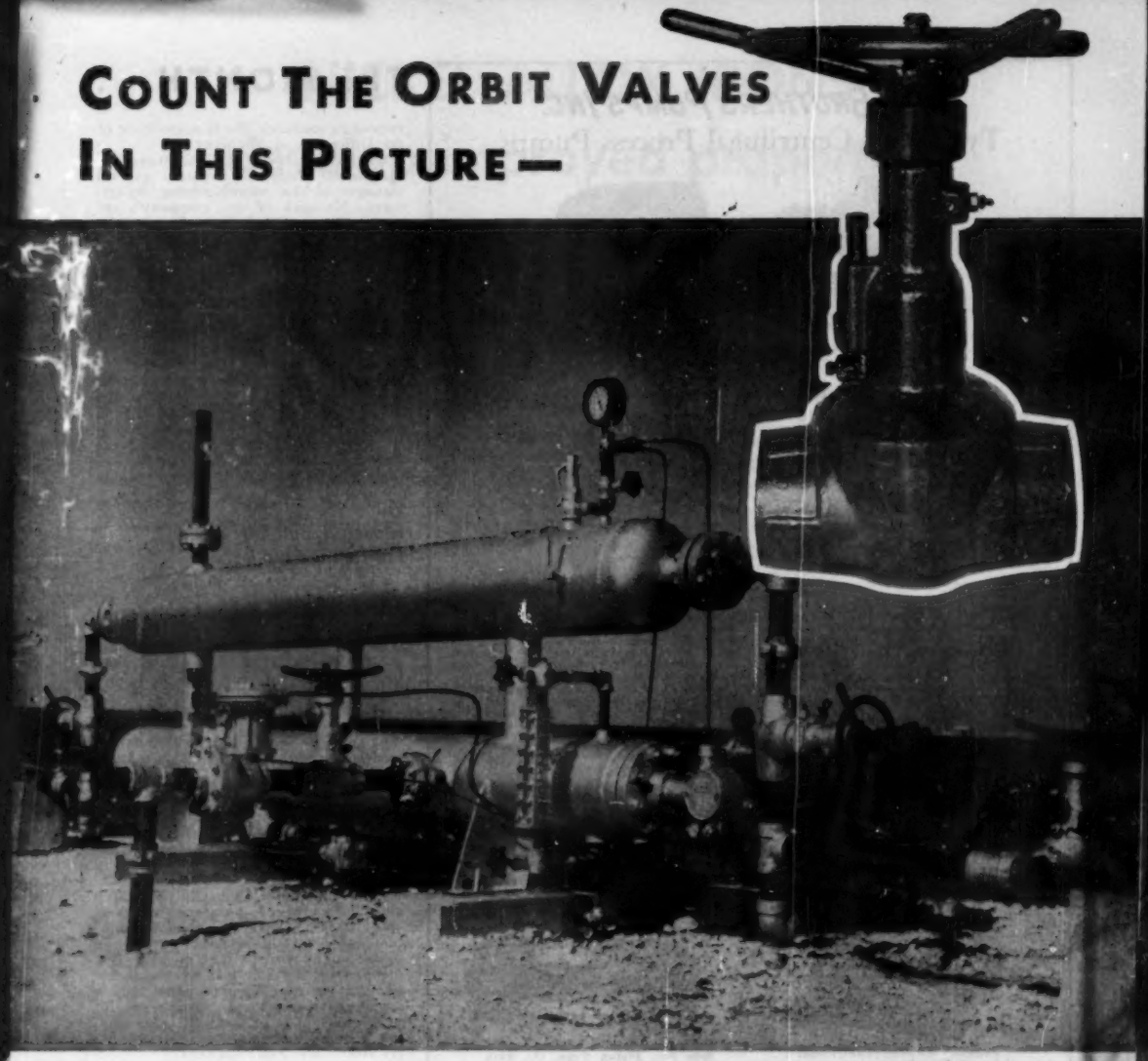

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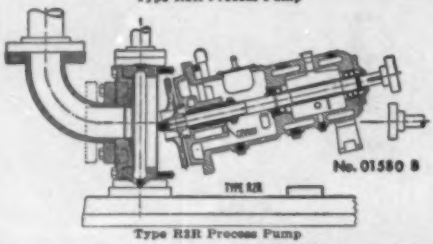

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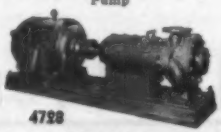

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The MONTH . . .

vanced to manager. He is a graduate of the University of Michigan.

On January 1, Dr. R. C. Gunness will assume the duties of assistant general manager of the manufacturing department. Manager of the company's research department, he is on leave at the present time, serving as vice chairman of the research and development board of the Department of Defense in Washington.

J. H. Forrester of Oklahoma City, has been appointed manager of research for Standard Oil Company (Indiana) and will leave his current job as manager of the Central Division of the Stanolind Oil and Gas Company. Forrester, a Texan who took undergraduate work at the University of Wisconsin and an M.S. in chemical engineering from Massachusetts Institute of Technology, has since 1929 held various positions in the research department of the Standard Oil Company.

Maschal, Sun Oil, Cited For Leadership Record

Charles E. Maschal, manager of Sun Oil Company's Marcus Hook refinery, was one of 60 alumni of Drexel Institute of Technology awarded citations for civic contributions and professional accomplishments at a convocation celebrating the 60 anniversary of the founding of Drexel Institute.

Maschal, who received his B.S. degree in civil engineering in 1931, was cited by the Institute for civic and indutrial leadership.

Dr. Schaad to Assist Raaen At UOP's Riverside Lab

Universal Oil Products Company has appointed Dr. Raymond E. Schaad to be technical adviser to Colonel J. C. Raaen, manager of Universal's Research and Development Laboratories at Riverside, Ill. Dr. Schaad, who recently completed 25 years of research, patent and development work with Universal, is a member of the American Chemical Society, a registered patent agent, and a registered professional engineer of Illinois. A graduate of Denison University, he received his Sc.D. degree in chemistry from Ohio State University.

Refinery Engineering Adds Koons to Projects Staff

Refinery Engineering Company has added Harold F. Koons to the staff in the capacity of project engineer. Koons, identified with the oil industry for over ten years as an engineer with Jones & Laughlin Supply Company and resident engineer, will make his home in Tulsa.

Grease Institute Elects 1952 Officers at Annual Meeting

The recent National Lubricating Grease Institute annual meeting in Chicago booked a record attendance of 446 delegates for the three day session. Retiring president Howard Cooper attributed the growth and strength of the Institute to wholehearted cooperation with other organizations.

Elected to fill three year terms on the

NICKEL ALLOY IRONS
develop improved properties
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PLAIN GRAY IRON is, structurally, a steel matrix containing graphite flakes. Engineering, physical, processing and service properties are wholly dependent upon the character and disposition of these flakes, and upon the nature of the matrix.

The matrix of nickel alloyed irons closely resembles the pearlitic matrix found in high carbon steels, whereas the matrix of ordinary plain iron resembles that found in low carbon steels. Compositions of nickel alloy irons can be adjusted to reduce "chill" in thin sections without risk of forming "spongy" regions in heavy sections. This promotes uniform strength, improved machinability, pressure tightness and wear resistance.

Hardness in nickel cast irons results from improvement of the matrix. Chilled areas and hard carbides, which impair machinability, are obviated. Nickel improves response to heat treating. In fact, use of nickel alone or with other alloying elements plays an important part in meeting a variety of requirements.

Accordingly . . . nickel alloyed irons permit production of castings with high levels of the following properties:

Strength

Tensile and transverse strengths of castings are greatly increased by the addition of nickel to cast irons of properly adjusted base mixture. The ratio of compressive strength to tensile strength is retained. Greater uniformity of strength in thick and thin sections is achieved.

Elasticity

The elastic modulus increases with strength. In this respect nickel-containing irons of the high strength type possess good stiffness and do not deform permanently under loads that would be damaging to irons of lower elastic modulus.

Damping Capacity

The damping capacity inherent in gray cast iron is not impaired by the presence of nickel.

Wear Resistance

The uniformly pearlitic matrix of nickel cast irons appreciably improves wear resistance. The uniformly fine graphite flake distribution, achieved in suitably processed irons *without formation of a poor wearing dendritic condition,* affords optimum resistance to wear and galling.

Pressure Tightness

Characterized by dense grain structure and fine dispersion of graphite throughout, nickel alloy irons are close-grained and offer an extraordinary degree of pressure tightness under high hydrostatic pressures, without sacrificing machinability.

Applications

Heavy machinery frames and *beds* are typical of cast parts that benefit from the rigidity and good damping capacity of nickel cast irons. *Cylinder* and *pump liners, gears, dies, machine tool ways, saddles* and *tables* exemplify parts produced in nickel irons to assure greatly increased strength and wear resistance. And nickel alloyed iron is used for *heavy duty brake drums* to resist heat checking, thermal shock, wear and galling. The nickel cast irons are readily heat treated, and respond particularly well to flame and induction hardening.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of engineering nickel cast irons for many end uses in defense and defense supporting industries.

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The MONTH . . .

board of directors were: M. R. Bower, Standard Oil Company (Ohio); A. J. Daniel, Battenfeld Grease & Oil Corporation; F. E. Rosenstiehl, The Texas Company; G. A. Olsen, Sunland Refining Corporation; W. H. Saunders, Jr., International Lubricants, Inc.; and B. G. Symon, Shell Oil Company.

The executive committee for the 1952 NLGI are: president, George E. Merkle, Fiske Brothers Refining Company; vice president, Wayne W. Albright, Standard Oil Company (Indiana); and treasurer, C. B. Karns, Esso Standard Oil Company.

Lawrence President of New Mechanical Design Company

A new firm, Mechanical Design, Incorporated, has been organized with offices at 517 Wright Building, Tulsa. Offered is a complete mechanical engineering and design service to the petroleum industry with a specialty of refinery and gasoline plant design.

Officers include J. R. Lawrence, president; Herbert E. Dyer, vice president and manager, Maloy Stevenson, secretary and Huff D. Peters, treasurer.

Battson Continental Director

E. F. Battson, administrative vice president of Continental Oil Company, has been elected to the board of directors. He replaces W. C. MacMillan, senior vice president, who resigned as director due to ill health.

MacMillan, 56, died last month in Glendale, Calif.

Conoco Platforming Unit Now Under Construction

Part of the huge expansion program at Continental Oil Company's Lake Charles, La., refinery will be the addition of a new UOP platforming unit for production of benzene and toluene. The unit will have a charge capacity of 5000 barrels daily for aromatic production or 6000 barrels when used for production of high quality motor fuel. Procon, Inc. will begin construction of the unit this month.

Synthetic Phenol Plant To Utilize New Process

To be the first plant of its type in the west, the synthetic phenol plant announced by Standard Oil Company of California for its Richmond refinery will cost $4 million, and in operation will utilize a recently-developed synthesis process in which neither sulfuric acid nor chlorine is used. Output from the plant will be marketed by Oronite Chemical Company, a subsidiary.

Heyden Plans Houston Petrochemical Plant Soon

A $12 million plant designed "basically" for the production of methanol from natural gas is being designed for the Heyden Chemical Corporation for erection commencing sometime during the first quarter of 1952, on the Houston ship channel between the Mathieson Chemical Corporation and Phillips Petroleum fertilizer plants.

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W-S Bulletin A3-50 details the Carbon Steel Line. Bulletin S-1 is devoted to Stainless and the Alloys. W-S will gladly furnish information on the new FEATHERLITE Fittings — a recent big step in a wide range of services. Write today for the specific bulletin you desire.

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BOOKS

Petroleum Standards

ASTM Standards on Petroleum Products and Lubricants (With Related Information), American Society for Testing Materials, 1916 Race Street, Philadelphia. $5.75.

This 1951 compilation of ASTM Standards brings together in compact, readily usable form, most of the standards, test methods, and specifications widely used in this field. New material includes tentative test methods for total inhibitor content of butadiene, bromine number of petroleum distillates, reduced pressure distillation of petroleum products, and hydrocarbon waxes used for electrical insulation.

NACE Report

Report of the Correlating Committee on Cathodic Protection, National Association of Corrosion Engineers, 919 Milam Building, Houston. Price, 50 cents.

Authentic recommendations for correlating cathodic protection systems on underground metallic structures are given, as well as a consolidation and revision of the four bulletins prepared by the committee to aid in solving problems created when adjacent underground metallic cables, pipe lines and rail track are protected from corrosion by applied cathodic currents.

Hazards Defined

Handbook of Dangerous Materials, N. Irving Sax, Reinhold Publishing Corporation, 330 West 42nd Street, New York, N. Y. $15.

Over 5000 hazardous industrial materials, including trade-name products are discussed in this heavy volume dealing with safety. Simple, concise and authoritative statements on dangerous properties of products are given. This might well prove the "bible" of safety engineers, plant superintendent and anyone involved in handling and shipping dangerous materials.

Protecting Discovery

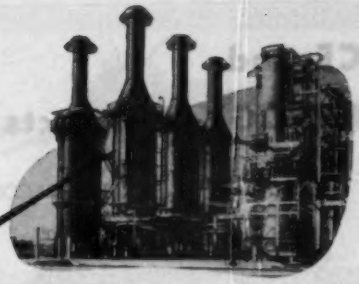
Patents for Technical Personnel, Dr. Worth Wade, Chemonomics, Inc., 400 Madison Avenue, New York. $3.

A ready handbook on patents, their development and current practice, Dr. Wade has compiled his experience and knowledge as a registered patent attorney and chemist, to extend "a word to the wise." Don't look for case histories or legal technology, this is a simple, accurate discussion of patent definition, and procedure for registering to protect your discovery.

Metallizing Process

New Metallizing Handbook, Metallizing Engineering Company, Inc., Long Island City, N. Y. Price $3.

A comprehensive coverage of the technical as well as practical aspects of the metallizing process is contained in this treatise which also reviews the various methods of surface preparation and the application of metallized coatings. Details for treating different surface conditions are offered.



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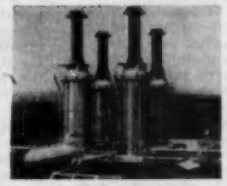
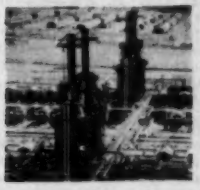
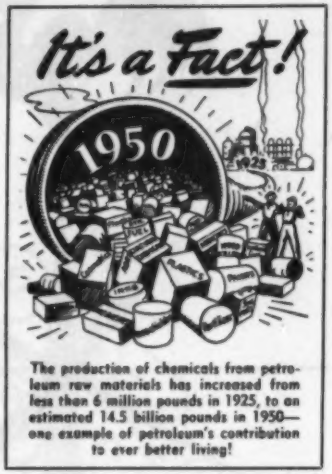




SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.



The production of chemicals from petroleum raw materials has increased from less than 6 million pounds in 1925, to an estimated 14.5 billion pounds in 1950—one example of petroleum's contribution to ever better living!

Fundamental Physical and Chemical Data

The Vapor Pressure and Critical Constants of Normal Pentane, JAMES A. BEATTIE, SAMUEL W. LEVINE AND DONALD R. DOUSLIN. *Jour Am. Chem. Soc.*, **73** (1951), pp. 4431-2.

The vapor pressure of normal pentane was measured from 100° C. to the critical point. A number of isotherms in the critical regions were studied to permit location of the critical constants. An equation is given that represents the vapor pressure data. The critical constants were found to be $t_c = 196.62 \pm 0.05°$; $p_c = 33.31 \pm 0.05$ normal atmosphere; $v_c = 0.295$ liter/mole (4.09 ml/gm); $d_c = 3.39$ moles/liter (0.244 g/ml). The uncertainty in the critical volume and density is approximately one percent. Data are presented in tabular and graphical form and a bibliography is included with references to previous work on this general subject.

An Empirical Equation for Thermodynamic Properties of Light Hydrocarbons and Their Mixtures. Fugacities and Liquid-Vapor Equilibria, MANSON BENEDICT, GEORGE B. WEBB, AND LOUIS C. RUBIN. *Chem. Eng. Progress*, **47** (1951), pp. 449-54.

Three previous papers in the series have described a group of empirical equations for representing certain thermodynamic properties of mixtures of light hydrocarbons in the gaseous and liquid phases. The present paper compares the liquid-vapor equilibria for twelve mixtures of hydrocarbons. The hydrocarbons included are methane, ethylene, ethane, propane, isobutane n-butane, n-pentane, and n-heptane. It was concluded that the equation can be used with confidence to predict liquid-vapor equilibria for the hydrocarbons listed. Data are presented in detail in tabular and graphical form and a bibliography of 17 references is included.

Synthesis and Mass Spectra of Some Hexa-, Hepta- and Octa-deuterated Derivatives of Propane. FRANCIS E. CONDON. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 4675-8.

A study of spectra and molecular structure were made for the purpose of increasing the usefulness of spectrometric methods of analysis. Infrared and mass spectra were obtained for propane-1,1,1,3,3,3-d_6 and propane-d_8, acetone-d_6, propane-1,1,1,3,3,3-d_6-2-ol, propane-d_7-2-ol, 2-chloropropane-1,1,1,3,3,3-d_6, and 2-chloropropane-d_7. These spectra were compared with those of propane, acetone, 2-propanol and 2-chloropropane.

The Heats of Vaporization and Vapor Heat Capacities of Some Dimethyl Cyclohexanes. J. P. MCCULLOUGH, W. B. PERSON AND RALPH SPITZER. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 4069-71.

The vapor heat capacities and heats of vaporization of cyclohexane and four isomeric dimethylcyclohexanes were measured in a flow calorimeter system. The measurements were made in the temperature range 400 to 500 degrees K. Expressions are given for the specific heats that represent the data. A comparison was made between the experimental heat capacity data and values calculated by the method of methyl increments. This showed the calculated values to be significantly high. However the structural concepts on which the semi-theoretical computations were based are given further verification by the consistent results for the dimethylcyclohexanes. The data are given in detail in tabular form.

Vacuum Ultraviolet Absorption Spectra of Cyclic Compounds. I. Cyclohexane, Cyclohexene, Cyclopentane, Cyclopentene and Benzene. LUCY W. PICKETT, MARGARET MUNTZ AND E. M. MCPHERSON. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 4862-5.

The molecular structure of five- and six-membered ring compounds has been a subject of much discussion and conflicting evidence. In order to supply data that can be used in a study of the molecular structure of these compounds the ultraviolet absorption spectra of the five- and six-membered ring hydrocarbons, cyclohexane, cyclohexene, cyclopentane, cyclopentene and benzene, were measured between 45,000 and 64,000 cm^{-1}. Measurements of intensity were made by a photographic method, using the compounds as vapors in a flowing system to minimize photodecomposition. Values of oscillator strength were calculated.

Thermodynamic Data of Benzene and Benzene Vapor. BRUNO RIEDIGER (Berlin-Hermsdorf, Germany). *Chem.-Ing.-Tech.*, **23** (1951), pp. 272-6.

Through analysis and correlation of the data in the literature a P.V.T. table was established for benzene and benzene vapor. The data are presented as a function of temperature and pressure, respectively. Enthalpies and entropies are included. Although the data may be somewhat in error on an absolute basis, they should be consistent relatively and should be reliable for differences.

Dicyclic Hydrocarbons. III. Diphenyl- and Dicyclo-Hexylalkanes Through C_{10}. KASPER T. SERIJAN AND PAUL H. WISE. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 4766-9.

Several classes of dicyclic hydrocarbons have been synthesized and purified at the laboratory of the National Advisory Committee for Aeronautics as part of a program concerned with studying possible components of aviation fuel. The present paper describes all the diphenyl- and dicyclohexylalkanes from C_{13} through C_{18}. A further objective of the hydrocarbon research program is the correlation of molecular structure with physical constants. Melting or freezing point values are reported for each hydrocarbon, as well as heats of combustion and viscosities. The synthesis and purification of the compounds are described and the data taken are presented in detail in tabular form.

These abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original article will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also will be prepared and furnished by arrangement with the Laboratories.

Chemical Composition and Reactions

Inert Gas Effects in the Oxidation of Hexane. B. J. H. SMALL AND A. R. UBBELOHDE. *Nature*, **168** (1951), pp. 201-2.

When hydrocarbons are oxidized in the gaseous phase at low temperature a peroxide radical is formed. This reacts further with RH to give ROOH—R. Energy of the first reaction must be stored briefly in the RO_2 radical. Stored energy can be used in the subsequent reaction process provided the second reaction occurs before collisions in the gas phase permit competitive deactivation by any third substance X. In the oxida-

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Moist air...

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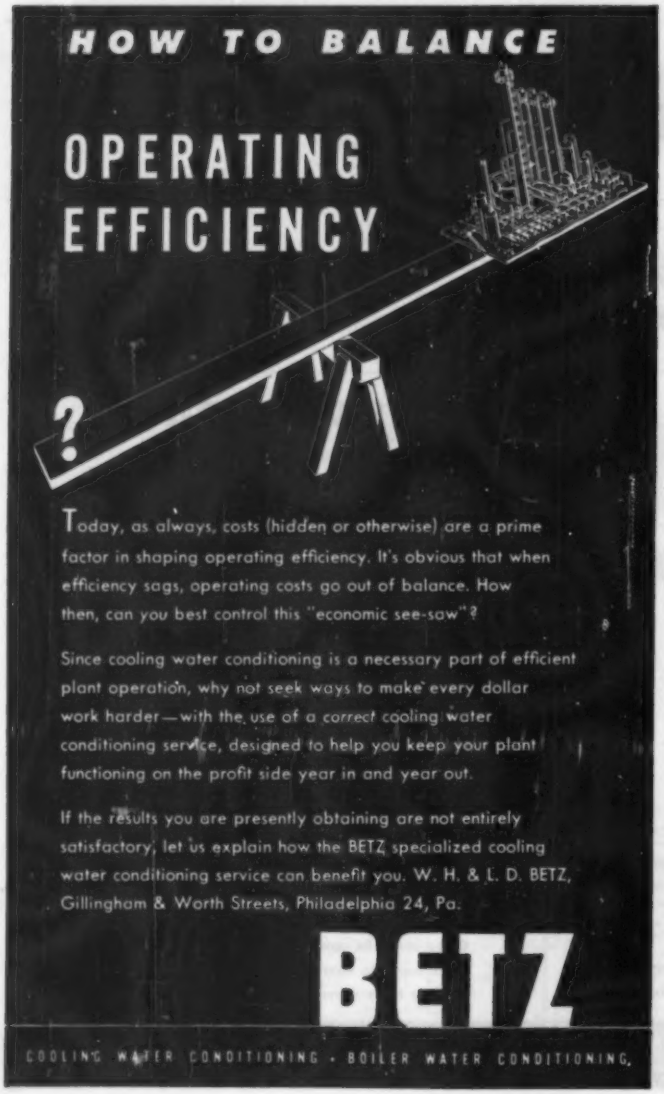
tion of gaseous acetaldehyde, dilution with hydrogen has a more inhibitory effect than dilution by nitrogen. Hydrogen also specifically inhibits hexane oxidation. These effects probably arise from energy-transfer processes in which collision with hydrogen is more efficient than collision with nitrogen. Traces of mercury vapor decrease the rates of oxidation. It is believed that the effect of hydrogen in suppressing the formation of cool flames in pentane may be related to the phenomena studied in the present investigation.

Low-Temperature Oxidation of n-Heptane and Methylcyclohexane. Vapor Phase Oxidation of Hydrocarbons. Part I. Aldehydes, Ketones and Acids Produced During the Low-Temperature Oxidation of n-Heptane and Methylcyclohexane. F. H. GARNER AND D. S. PETTY. *Trans. Faraday Soc.*, **47** (1951), pp. 877-84.

In the oxidation of the higher paraffin and cyclic hydrocarbons, a low-temperature and a high-temperature range can be distinguished. The low-temperature reactions are associated with cool flames and the production of aldehydes and other intermediate oxidation products. At the high temperatures the reaction products are mainly carbon dioxide and water. The authors studied the low-temperature oxidation of n-heptane in the range 250°-400° C., and of methylcyclohexane in the range 325°-400° C. Liquid products were analyzed for the total amounts of various types of organic compounds. High molecular weight aldehydes and ketones, as well as carboxylic acid and formaldehyde, were formed from n-heptane and from methylcyclohexane. It is believed that the carboxylic acids are formed by some mechanism other than direct oxidation of aldehydes. Acetic acid was the principal carboxylic acid formed. Formaldehyde was not formed by the degradation of higher aldehydes.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Carboxylic Acids Formed in the Slow Oxidation of n-Heptane. The Oxidation of Hydrocarbons. Part I. The Carboxylic Acids Formed in the Slow Oxidation of n-Heptane. T. L. RAINE AND F. H. GARNER. *Trans. Faraday Soc.*, **47** (1951), pp. 896-9.

When n-heptane is oxidized, a large number of aldehydes, ketones, acids and alcohols are formed. The relative proportion of carboxylic acids present was determined, and from these data conclusions can be drawn as to the probable nature of the aldehydes formed. Slow oxidation of n-heptane was conducted in the range 305°-480° C. to find out what carboxylic acids were produced, and in what amounts. Separation of the acids was made chromatographically. Formic and acetic acids were found to predominate, but some higher acids were present. When temperature increases, the percentage of acetic acid increases and formic acid decreases, as do higher carboxylic acids. The average molecular weight of the acids formed at all temperatures was between 57.1 and 58.0.

Alumina Activated with Anhydrous Hydrogen Fluoride. A Dealkylation Catalyst for Aromatic Hydrocarbons. LLOYD BERG, E. O. KINDSCHY, W. S. REVEAL, AND H. A. SANER. *Chem. Eng. Progress*, **47** (1951), pp. 469-72.

The work reported was undertaken to evaluate hydrogen fluoride activated alumina as a dealkylation catalyst for aromatic hydrocarbons. All dealkylation runs were made at essentially atmospheric pressure and at a space velocity of 0.5 volume/(volume of catalyst) (hr.). The aromatics studied included toluene, xylenes, ethyl benzene, diethylbenzenes, isopropyl benzene, monoamyl benzene, diamyl benzenes, and triamyl bensenes. Benzene was found to be the ultimate dealkylation product of every aromatic hydrocarbon containing two or more carbon atoms in the branch chain, while toluene was the ultimate dealkylation product of any aromatic hydrocarbon containing only one carbon atom in any of its branch chains. Dealkylation increased with rising temperature and alkylation decreased. All aromatic dealkylation products were the results of carbon-carbon fission at the benzene ring. A bibliography of 15 references is included.

Aromatizing Cracking of Hydrocarbon Oils. Process Data and Mechanism. CHAIM WEIZMANN, ERNST BERGMANN, W. E. HUGGETT, HERBERT STEINER, AND MAX SULZBACHER WITH DONALD PARKER, K. O. MICHAELIS, SYDNEY WHINCUP, AND EMANUEL ZIMKIN. The Weizmann Institute of Science, Rehovoth, Israel. *Ind. Eng. Chem.*, **43** (1951), pp. 2312-18.

This is the first of four papers having to do with the formation of aromatic hydrocarbons. The high temperature

aromatization of hydrocarbons proceeds largely through degradation to small unsaturated compounds, among which butadiene is important, and through subsequent "diene reactions" through which hydroaromatic hydrocarbons are formed that eventually dehydrogenate to aromatics. If the charging stock is naphthenic, the direct thermal dehydrogenation of the naphthenes is a second source of aromatics. A process is described that converts a nonaromatic, or partially aromatic, charging stock into liquid and gaseous products. The gases are predominantly unsaturated, that is ethylene, propylene, butylene, isobutylene, and some butadiene. The liquid product is 90 to 98 percent aromatic and substantially free of sulfur and nitrogen, even in those cases in which the charging stock contained sulfur and nitrogen compounds. The whole range of aromatics from benzene to the most complicated polycyclics are obtained practically without reference to the size of the charging stock. The process thus yields practically all the hydrocarbons required by the modern organic chemical industry and can supplement or replace both the usual cracking processes and the coal tar industry. It is being used at the present time on an industrial scale in England.

Polycyclic Fractions. CHAIM WEIZMANN, ERNST BERGMANN, H. S. BOYD-BARRETT, HERBERT STEINER, AND MAX SULZBACHER, WITH J. R. HOLKER, ERNA MANDEL, JOHN PORGES, AND DERRICK ROWLEY. The Weizmann Institute of Science, Rehovoth, Israel. *Ind. Eng. Chem.*, **43** (1951), pp. 2318-21.

The paper deals with the components of the aromaticized product from a naphthenic naphtha, which components boil above approximately 200° C. These are the hydrocarbons related to naphthalene, anthracene, and chrysene. An explanation is given of the mechanism of the formation of the polycyclic aromatics. Although many of these compounds are identical with typical components of coal tar, the mechanism of their formation seems diametrically opposed in the two cases. Coal tar is considered as a degradation product from high molecular weight coal. Polycyclic hydrocarbons from the aromatization process are the result of the stepwise synthesis from low molecular weight compounds.

Influence of the Nature of Charging Stock. CHAIM WEIZMANN, ERNST BERGMANN, W. E. HUGGETT, HERBERT STEINER, AND MAX SULZBACHER WITH K. O. MICHAELIS, FELIX POPPER, SYDNEY WHINCUP, AND EMANUEL ZIMKIN. The Weizmann Institute of Science, Rehovoth, Israel. *Ind. Eng. Chem.*, **43** (1951), pp. 2322-5.

Several charging stocks for aromatization were characterized and compared, including Fischer-Tropsch distillate, Iranian naphtha, East Texas naphtha, cracked East Texas naphtha, Naphthenic naphtha, East Texas naphtha sulfur dioxide extract, and coal tar distillate. Olefins are aromatized more easily than paraffins, and naphthenes give a still higher yield. Branched chain paraffins give higher yields than normal paraffins. Comparison is made of the yields of aromatics found by experiment with those calculated by two different methods. A bibliography of 15 references is included.

Conversion of Butylene Into Aromatics. CHAIM WEIZMANN, VICTOR HENRI, AND ERNST BERGMANN. The Weizmann Institute of Science, Rehovoth, Israel. *Ind. Eng. Chem.*, **43** (1951), pp. 2325-6.

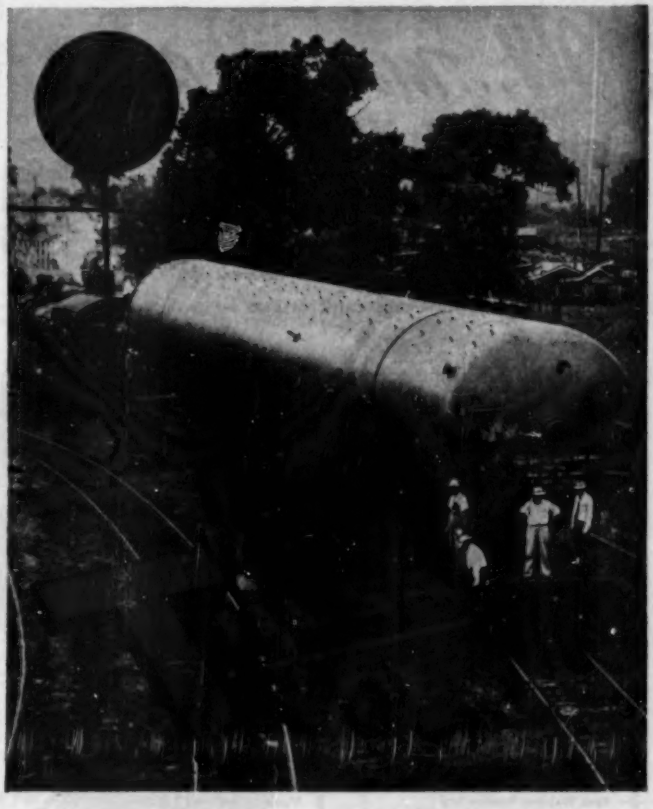
A study was made of the formation of aromatics from butylenes. Butylene is not a good charging stock because since the formation of aromatics requires butadiene it is more difficult to start with butylene from which butadiene is not readily formed. Data are given on the aromatics formed in the presence of various catalysts, such as copper, silica, zirconium oxide, thorium oxide, cerium oxide, and other rarer oxides. A number of parallel experiments were carried out using propylene. The aromatics in the xylene boiling range were found to be largely ethylbenzene and styrene. A bibliography of 13 references is included.

Science and Technology

Manufacture: Processes and Plant

Statistical Design in Chemical Experimentation. W. L. GORE. *Ind. Eng. Chem.*, **43** (1951), pp. 2327-8.

Because research is unusually important in chemical and process enterprises, statistical techniques for the analysis of experimental data becomes important. Most research men, however, are not



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aware of the value of statistical design principles in planning experimental programs. A general plan, believed to be useful for investigating phenomenon caused by the display of several variables, is described. Examples in connection with the rate of polymerization reactions are given. Thirteen variables are listed that may be considered to have major or lesser effect on the polymerization reaction. To evaluate all 13 of the variables and their interactions, a minimum of $2^{13} = 8192$ experiments would be required. Since this is neither desirable nor possible, it becomes important to evolve a plan reducing the number of experiments required. The manner in which this can be done is described.

The Effect of Bubble-Cap Diameter Upon the Performance and Capacity of Rectifying Plates. EMIL KIRSCHBAUM. *Chem.-Ing.-Tech.*, **23** (1951), pp. 213-22.

A rectifying column approximately 30 inches in diameter and having five plates at approximately 8-inch spacing, was studied using a series of bubble caps of 35, 50, 70, 90, 145, 200, and 425 mm. diameter. Test solution was ethyl alcohol-water. The smallest caps gave a maximum rate 2½ to 3½ times as great as the largest caps. If loading is determined by entrainment and the plate area is within the economic optimum range, the maximum allowable vapor velocity is given by the expression $W_D = (0.00655/u)(\gamma_F/\gamma_D)H$ where γ_F and γ_D are the specific gravity of the liquid and vapor, respectively, in kg./cu.m., H is the plate spacing in meters, u is the circumference ratio, that is the empty tower cross section/sum of bubble-cap circumferences. The numerical constant is characteristic for the system ethyl alcohol-water. Data are presented on pressure drop and on optimum cap diameter.

Chemical Engineering Materials of Construction. *Ind. Eng. Chem.*, **43** (1951), pp. 2193-2294.

Industrial and Engineering Chemistry presents the fifth annual Chemical Engineering Materials of Construction Review. Fifteen articles are included covering the construction material literature of the past year on aluminum alloys, carbon and graphite, cement, ceramics, wrought copper and copper base alloys, elastomers, fibers, iron, mild steels and low-alloy steels, nickel and high-nickel alloys, paint, hard rubber, stainless steels and other ferrous alloys, tin and its alloys, wood, and the less common metals. Following these reviews is a section on the properties of chemical engineering materials of construction in data form.

Symposium on Plant Cost Estimation. *Ind. Eng. Chem.*, **43** (1951), pp. 2295-2311.

Industrial and Engineering Chemistry presents a symposium on plant cost estimation, including articles on Capital Cost Estimating, Preliminary Estimating by Selective Unit Costs, Estimating Construction Costs in Chemical Process Industries, Preliminary Estimation of Operating Costs, Inflation in Production and Operating Costs, and Pre-design Cost Estimates.

Products: Properties, Utilization and Analysis

Relation of Octane Number to Cool Flame Formation. M. R. BARUSCH AND J. Q. PAYNE. California Research Corporation, Richmond, Calif. *Ind. Eng. Chem.*, **43** (1951), pp. 2329-32.

Various explanations of the knock in gasoline engines have been advanced. One of the most popular is that in the unburned fuel-air mixture ahead of the flame front, preflame reactions occur that set the stage for a more rapid and violent ignition, which is knock. It has also been suggested that the preflame reaction causing knock is the same as that which causes the so-called cool flames. The investigation was undertaken to determine the possibility of stabilizing a cool flame in a straight tube and further, to study the relationship between octane numbers and the tendency of fuels to produce cool flames. An apparatus was developed in which stationary cool flames could be obtained. The stable or equilibrium position of the flame was a function of temperature, flow rate, and composition of the fuel. Pressure and fuel-air ratio were maintained at constant values. As temperature was decreased or flow rate increased, the cool flame moved away from the inlet of the tube. To establish a correlation between octane number and cool flame position blends of iso-octane and n-heptane were used. Tendencies of other hydrocarbons to produce cool flames and the effect of antiknock additives and also of a prodetonant were studied in rela-

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tion to octane number. It was found that the resistance of a fuel to knock appears to be controlled principally by its resistance to cool flame formation. A bibliography of seven references is included.

Determination of Free Sulfur in Gasoline. KARL UHRIG AND HARRY LEVIN. *Analytical Chem.*, **23** (1951), pp. 1334-5.

One reason for the possible presence of free sulfur in gasoline may be the excessive addition of sulfur in the doctor sweetening process. Sulfur is corrosive to metal and has an adverse effect on oxidation inhibitors and on tetraethyllead. The method of determination described was developed as a rapid and simple control test for the doctor sweetening operation. Elementary sulfur combines readily with mercury. Because of this and because mercury does not react with mercaptans, it was selected as the basis of the method described. 100 cc. of the unknown gasoline is treated in a narrow mouth, 4-ounce bottle with two cc. of oleic acid and three cc. of mercury. The bottle is stoppered and shaken for five minutes and compared with standard suspensions.

Determination of Tetraethyllead in Gasoline by X-Ray Absorption. SAMUEL W. LEVINE AND A. H. OKAMOTO. *Analytical Chem.*, **23** (1951), pp. 1293-6.

The quantitative chemical determination of tetraethyllead in gasoline is a slow and tedious process. X-ray absorption methods are faster, but must take into account various complicating factors, for the x-rays are absorbed to a certain extent by contaminants in the gasoline as, for example, by sulfur. The authors describe an x-ray absorption method in which total absorption is used as a measure of tetraethyllead content and therefore a correction must be made for the surfur absorption. Several fundamental factors not mentioned by other workers were found to have a significant effect on accuracy, particularly when analyzing gasolines of different base stocks having different ratios of carbon to hydrogen and different densities. The method developed and described permits the analysis of a sample in a total time of 10 to 15 minutes with an accuracy of ±0.02 ml. of tetraethyllead per gallon. The method is thus well suited for control work as well as for other analytical needs.

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2-Ethylhexanedithiol-1,3
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1,1-Diiodo-2-methylpropane
Propylene tetramer

Science and Technology

Pan American Refining Award Given Charles Hobbs, Jr.

Charles C. Hobbs, Jr., University of Oklahoma graduate student from Ryan, Okla., has been reappointed to receive the Pan American Refining Corporation fellowship in chemistry for the 1950-51 year. Hobbs holds B.S. and M.S. degrees in chemistry from the University and plans to do industrial research after completing his Ph.D. degree.

Offers Tank Truck Movie

In order to help the petroleum industry dispel some commonly held misconceptions concerning the safety of gasoline transfer by tank truck, E. I. Du Pont de Nemours & Company, Wilmington, Del., has produced a full-color sound movie on tank truck safety. This film is available to oil companies. Entitled "Pipe Line on Wheels," the film is specially designed to give the facts about safety features found in tank trucks built today. It presents an entertaining human-interest story.

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A6	B6	C6	D6	E6	F6	G6	H6	J6	K6	L6	M6	N6	P6	Q6	R6	S6	T6	U6	V6
A7	B7	C7	D7	E7	F7	G7	H7	J7	K7	L7	M7	N7	P7	Q7	R7	S7	T7	U7	V7
A8	B8	C8	D8	E8	F8	G8	H8	J8	K8	L8	M8	N8	P8	Q8	R8	S8	T8	U8	V8
A9	B9	C9	D9	E9	F9	G9	H9	J9	K9	L9	M9	N9	P9	Q9	R9	S9	T9	U9	V9
A10	B10	C10	D10	E10	F10	G10	H10	J10	K10	L10	M10	N10	P10	Q10	R10	S10	T10	U10	V10

Name (Please Print)_____

Company_____ Position_____

Address_____

MAIL IT NOW . . . *CARD EXPIRES MARCH 10, 1952

New Catalogs AND EQUIPMENT LITERATURE

Use one of the free and convenient Reader Service Postcards on this page to request copies of the catalogs in which you are interested.

Heat Processing

Heat processing is approached through five basic considerations in the new bulletin issued by Selas Corporation of America. What is to be heated; what sections are to be processed; why; to what temperature; and heating time, are the conditions considered. The bulletin illustrates the application of high-production heating principles to solid and fluid products ranging in size from mill operations to delicate enameled pieces.

Circle No. 6 on Postcard

Laboratory Supplies

Andrew Technical Service has announced a bulletin which describes synthetic rubber pails for handling acids, portable self-contained blow torches with disposable fuel containers, precision movement stop watches, and a new humidity indicating card which shows humidity at a glance. Several other items of general laboratory utility are included.

Circle No. 7 on Postcard

Flexible Heating Cable

Thermwire, a new flexible electric heating cable, is described in a brochure by Edwin L. Wiegand Company, manufacturers of Chromalox electrical heating units. The cable consists of a heavy-gauge nickel-chromium resistor wire with a tough abrasion-resistant insulating sheath. The Thermwire protects roofs, gutters, etc., from costly accumulations of snow and ice by melting such elements as they form.

Circle No. 8 on Postcard

Variables Controller

Tel-O-Set controllers, manufactured by Minneapolis-Honeywell Regulator Company, function designed for accurate control of process variables, such as temperature, pressure, flow and liquid level, are described in their new specification sheet. These models feature high sensitivity, instant response to process change and a pneumatic-balance principle of operation which eliminates lost motion and reduces friction to a minimum.

Circle No. 9 on Postcard

Bearing Seals

Klozure oil and grease seals for bearings are discussed in The Garlock Packing Company booklet which describes all types of Klozures, typical applications, and a complete list of sizes and part numbers. In addition it describes Garlock's Mechanical Pressure Seals for rotary shafts.

Circle No. 10 on Postcard

Resistance Welded Tubing

A chart by the Welded Tube Division of The Babcock & Wilcox Tube Company describes the new size range available in the electric resistance welded carbon steel tubing manufactured by the division. The chart is broken down to reflect both average wall and minimum wall requirements in .08/.18 percent and .20/.30 percent carbon steel grades.

Circle No. 11 on Postcard

(More Literature Items on Pages 193, 195, 197, 199, 201)

PETROLEUM REFINER Reader Service Postcard—December, 1951, Issue*

EDITORIAL ITEMS—Circle item numbers on which more information desired.

1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55
2	5	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	

ADVERTISEMENTS—Circle key number of ad for more product information.

A1	B1	C1	D1	E1	F1	G1	H1	J1	K1	L1	M1	N1	P1	Q1	R1	S1	T1	U1	V1
A2	B2	C2	D2	E2	F2	G2	H2	J2	K2	L2	M2	N2	P2	Q2	R2	S2	T2	U2	V2
A3	B3	C3	D3	E3	F3	G3	H3	J3	K3	L3	M3	N3	P3	Q3	R3	S3	T3	U3	V3
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Name (Please Print)_____

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USE THESE CARDS
To Get
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And for More
Information on
NEW EQUIPMENT
ADVERTISED PRODUCTS

NEW EQUIPMENT and Manufacturers' Literature

KEEP INFORMED by requesting additional information on new equipment and services described here. SAVE TIME by using the Reader Service Postcards on opposite page. Circle number on card corresponding to the number listed at the end of each new equipment item on which you desire additional information.

Pallet Loader

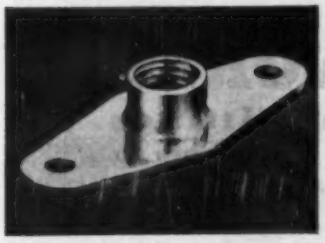
The Lamson Corporation has designed an automatic Pallet Loader arrangement for intermediate storage of pallets awaiting removal after being loaded. Six loaded pallets may be accumulated while waiting for the fork truck. Loaded pallets are pushed off the Pallet Loader's discharge conveyor and onto a second conveyor at right angles to the discharge. Automatic tripping mechanisms operate a ram which pushes the loaded pallet onto the right-angle storage conveyor. Manual pallet loading can thus be eliminated in mass production operations.

Circle No. 12 on Postcard

Motor-Driven Pumps

A new bulletin on Milton Roy motor-driven controlled volume pumps describes their use for pumping practically any liquid, from heavy viscous liquids to light solvents. Pump capacity can be regulated by plunger speed and plunger stroke adjustments.

Circle No. 13 on Postcard



Locking Anchor Nuts

Incorporating new features in self-locking anchor nuts, Kaynar Manufacturing Company's newest product is made of all spring-steel according to military aircorps specifications. It consists of a flanged anchoring portion integral with a thin-walled drawn shell which is fully tapped throughout its length. Harder than most bolts, and practically impossible to cross-thread, it requires a minimum of replacement. Because there are no locking "wings" or "lugs," it is extremely rugged and difficult to damage.

Circle No. 14 on Postcard

Cooling Towers

Aqua-therm Inc. has released a bulletin on its improved industrial cooling towers, featuring scrubbing and process towers of acid-proof construction, and containing acid-proof equipment.

Circle No. 15 on Postcard

Diesel Driven Compressor

The new Standard Model 365 air compressor manufactured by The Jaeger Machine Company features a diesel drive by the Cummins Engine Company, Inc. The compressor, rated at 365 cubic feet of air per minute at 100 psi., utilizes a 165 hp. Model HRBI-600 Cummins diesel for its power plant. The operating speed of the unit is 1240 rpm. Both the diesel and compressor are mounted on structurally welded main frames which have "auto-steer" front axles, and can be hauled at 35 mph. over rough roads. Steel wheels or skid mountings are available.

Circle No. 16 on Postcard

Sump Filters

Engineering data on synclinal type filters for sump or line installation on all hydraulic and low pressure liquid recirculating systems is contained in the recent folder by The Marvel Engineering Company. Filter mesh runs from 30 to 200; capacity ranges from 5 to 100 gpm. sizes.

Circle No. 17 on Postcard

Pitch Level Determinator

By use of the True-Pitch Level, the exact pitch of a pipe or drain can easily be determined, according to Drier Brothers who invented and manufacture the device. Said to be accurate to a thousandth of an inch, the pitch is figured by aid of a table on the decal attached to the device and then set and locked in that position. When the bubble, which can be read from the top or either side, shows "level", the pipe is at the proper pitch, as set previously. It can be used as an ordinary level by setting the adjustment at zero. The Level is 20½ inches long and the frame is made of seasoned wood, chamfered for a secure finger grip. Metal parts are plated.

Circle No. 18 on Postcard

Automatic Titration

The Coleman Autotrator Model 19, for automatic titration, manufactured by Coleman Instruments, Inc., is said to provide precise, high speed, fully automatic titration at a minimum cost. The titrant is delivered rapidly until the end-point approaches, then is restricted; the final portions are added in progressively smaller increments until the true end-point is reached. Operation is controlled by the Coleman Model 18 ph. Electrometer which measures and continuously indicates the progress of titration. The instrument employs standard laboratory accessories and occupies a minimum of space. Coleman Bulletin B-223.

Circle No. 19 on Postcard

Centrifugal Pumps

Economy Pumps, Inc., Division of Hamilton-Thomas Corporation, has general purpose centrifugal pumps said to be well suited for any small pump application such as small cooling towers, domes- pump is of the close coupled type, and is equipped with mechanical seals. tic water supply, etc. This SCC converted to hori- ready a new line of ings, they can be pumps have standard vertical mount- Motors are of standard open drip type, and while zontal mounting. Impellers, wearing rings and mechanical seals are easily replaced.

Circle No. 20 on Postcard

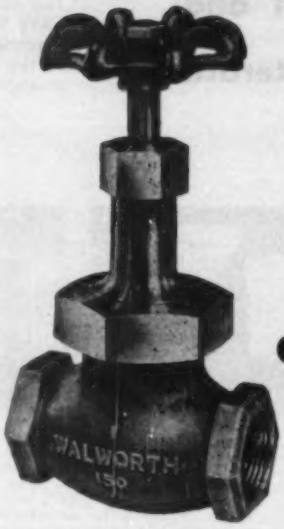
Toothed Lock Washer: Prevents loss of stem nut due to vibration, thereby holding the handwheel securely.

Newly Designed Handwheel: Air-cooled, finger grip handwheel affords sure grip even with greasy gloves.

Improved Packing: Molded packing of lubricated asbestos reinforced with copper wire. Suitable for practically every service. Valves can be repacked under pressure.

Hexagonal Union Bonnet Connection: Eliminates any chance of distortion or leakage even though valve is repeatedly taken apart and assembled.

WALWORTH



IMPROVED
No. 95
BRONZE
GLOBE VALVE

also available in Angle Type (No. 96)

The service ratings of the Walworth No. 95 are 150 pounds per square inch steam at 500F, and 300 pounds per square inch non-shock cold water, oil, and gas. In the manufacture of this quality bronze valve, more than 47 gages are used in machining parts to micrometric accuracy, thus insuring interchangeability of parts. For further information see your local Walworth distributor, or write: Walworth Company, 60 East 42nd St., New York 17, N. Y.

note these 7 Great Features

WALWORTH
valves and fittings

60 EAST 42nd STREET NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

New Cylindrical Disc Holder: The design of the top portion of the disc holder keeps the disc accurately guided under all operating conditions.

Renewable Asbestos Disc: This disc is suitable for steam up to 500F and is resistant to oil, gasoline, and many chemicals at atmospheric temperatures. Discs for special services are available.

Extra Strong Body: Made of Composition M (ASTM B61) bronze thick enough to provide a high safety factor. Valves undergo hydrostatic shell test of 450 psi.

To obtain additional information or literature use free Reader Service Postcard opposite page 192. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.

Head Covering

Standard Safety Equipment Company is now offering the Windsock, a warm light weight, throw-away type head covering to be worn under the safety hat. It is available in two ear covering lengths of 9- and 11-inches, and was especially designed for winter use to eliminate drafts under the hat and cradle. It also provides protection between the head and the cold surface of the safety hat.

Circle No. 21 on Postcard

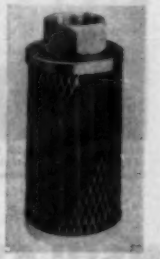
Dust Removal

Catalog No. 101 on the "Collection and Recovery of Industrial Dusts" is a new publication by Buell Engineering Company, Inc. It lists the benefits of removing dust, the definition of dust, and explanation of the factors which influence the choice of equipment for specific jobs.

Circle No. 22 on Postcard

Large Capacity Filter

Hydraulic and low pressure liquid recirculating machinery gets ample filter capacity when using Marvel Engineering Company's new Synclinal Filters which process 75 to 100 gallons per minute. The 75 gpm. filter is 12½ inches over-all, including the coupling nut, and 6 inches in diameter, with coupling to fit a 2½-inch pipe. The 100 gpm. model measures 14 inches over-all and 6½ inches in diameter. The filters feature no moving parts, and room for foreign matter accumulation between cleaning periods.



Circle No. 23 on Postcard

Wet-Pit Pumps

Worthington Pump and Machinery Corporation offers their new bulletin describing Freeflo Pumps for sump, sewage and drainage service to official company personnel. The FLJ and FLJD wet-pit pumps are described as having non-clogging sewage pump impellers capable of passing solids and stringy material. The stuffing box is placed above the impeller, and the pump bearings are above and separate from the box. Because the stuffing box is normally inaccessible, it is equipped with U-cup packing which requires no adjustment.

Circle No. 24 on Postcard

Drum Safety Valve

Ventadrum is the trade-name of a new safety valve designed to control the cause and eliminate dangerous explosions caused by pressure expansions in 50 gallon metal drums. Ventadrums are manufactured by Central Safety Equipment Company. Easily screwed into the buug opening of the universal type drum, the Ventadrum valve automatically functions under six rapid-action principles. Air is permitted to enter the drum on contraction of liquid or is permitted to escape slowly during expansion of liquid caused by normal temperature changes. Descriptive literature is available.

Circle No. 25 on Postcard

Water Purifier

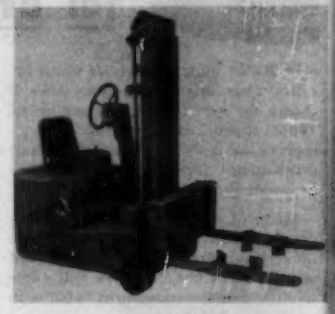
Bulletin 512 by Elgin Softener Corporation, describes the Elgin Ultra Deionizer with monoflo design. The single tank deionizers of mixed-bed, monoflo design gives up to 44 percent more capacity according to the manufacturer. It produces water of high chemical purity, free from ionizable impurities including carbon dioxide and silica. It replaces distillation or evaporation for as little as one to ten percent of the cost. A double-check design prevents loss of valuable ion-exchange resins.

Circle No. 26 on Postcard

One Knob Controller

Taylor Instrument Company has developed the Transet Bi-Act Controller for applications where it is desirable to transmit the measured variable to some remote location. Adaptable to flow, liquid level or pressure applications which require fast reset rates and broad throttling bands, it is designed for use where derivative action is not essential. The control circuit pneumatically links proportional and automatic reset responses together, while the one knob adjusts both proportional and automatic reset responses so that the processes can be brought to a stable condition with ease.

Circle No. 27 on Postcard



Hydraulic-Clamp Forks

To handle drums and other cylindrical objects, Lewis-Shepard Products has developed hydraulically operated clamping forks which can be fitted with self-aligning rubber faced gripping pads when required. They are used in conjunction with the new Spacemaster "49" Electric Fork Trucks. The minimum distance between the forks is 12 inches and the maximum is 27 inches. The gripping pads are mounted in pairs on sleeves that fit over the forks and can be readily removed so that the Fork Truck can be used in the conventional manner with pallets.

Circle No. 28 on Postcard

The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of ovens, stationary and marine boilers, auxiliary power plant equipment, stills, reactor chambers, regenerators, high temperature mains, heaters, flues, stacks, and other types of high temperature equipment.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

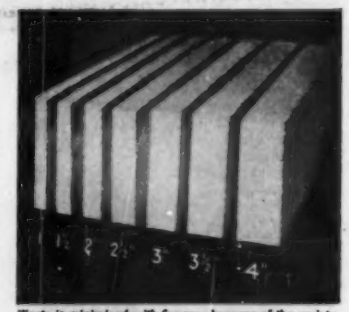
Light weight—Approximately 2 lb per sq ft per in. thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex ½ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 290, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.

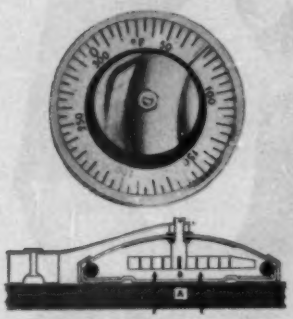


Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.

JOHNS MANVILLE JM PRODUCTS

Johns-Manville *first in* **INSULATIONS**

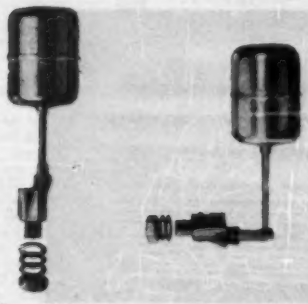
To obtain additional information or literature use free Reader Service Postcard opposite page 192. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.



Surface Thermometer

Pacific Transducer Company has announced a new surface temperature thermometer for fast and accurate checking of the outside temperature of pipes, plastic dies, and rubber molds. It is also applicable to checking the external temperatures for wall leakage of refrigerators, etc., and checking the temperatures of journals and other bearings, electric motors and cylinder blocks, as well as wall, ceiling and floor temperatures. Thermo-dynamically designed to produce an essentially unilateral thermal instrument it indicates the temperature from the back of the instrument only.

Circle No. 29 on Postcard



Float Valve

A new float-operated valve has been announced by McDonnell & Miller, Inc., for utilization on liquid level control jobs. It combines large capacity, sturdy, non-corrosive construction with simple design and operation. No. 18 consists of the valve mechanism and float. No. 118 is a variation designed for protection against back-siphonage, and has a float mounted at right angles to the valve to keep the valve proper above the water level. No. 518 includes a float and valve in a die-cast chamber, with a well-fitting cover. All three are designed for external applications. Except for the neoprene valve seat, all parts are made of copper or brass.

Circle No. 30 on Postcard

Tube Cleaner

Tube cleaner, Model-TP-301, is said to remove deposits from completely plugged heat exchanger tubes because of its powerful action, and does it in fewer man-hours according to Thomas C. Wilson, Inc. Improved specifications include, a light 15-pound weight, a shorter 13-inch overall structure, and increased capacity from ¾ to 3-inches O.D. Hollow shafting is available in one piece up to 20-feet, or in sectional threaded lengths. Minimum practical working headroom is five feet.

Circle No. 31 on Postcard

Submersible Pump

The Byron Jackson Company has introduced a small submersible pump designed for small capacities at high heads from wells of 6 inches inside diameter or larger. This pump has a capacity range of from 30 to 130 gpm. at heads of from 80 to 770 feet. The motors, available in sizes of 5, 7½, 10 and 15 hp., are three phase. The "Subette" eliminates alignment and bearing protection problems of shaft-type installations according to the manufacturer. Available in four motor sizes it is recommended for refinery use. Bulletin available.

Circle No. 32 on Postcard

Centrifugal Pumps

Economy Pumps, Inc., Division of Hamilton-Thomas Corporation, has ready a new line of general purpose centrifugal pumps said to be well suited for any small pump application such as small cooling towers, domestic water supply, etc. This SCC pump is of the close coupled type, and is equipped with mechanical seals. Motors are of standard open drip type, and while pumps have standard vertical mounting can be converted to horizontal mounting. Impellers, wearing rings and mechanical seals are easily replaced.

Circle No. 33 on Postcard

Thermocouple Wells

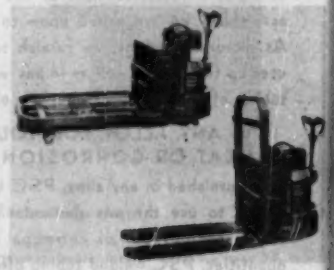
Catalog 200-1 provided by Minneapolis-Honeywell Regulator Company, gives technical information concerning the selection of the proper thermocouple well for any given application. Guidance on proper selection of well material, and curves for well shape and thickness selection are included.

Circle No. 34 on Postcard

Diaphragm Switch

Compactness and simple design are incorporated into the General Controls Company new diaphragm switch known as the L-38 Low Pressure Switch. The switch is actuated by gas pressure and is applicable to heating plant installations where the switch is opened by a variation in gas pressure. Pressure applied against a spring loaded diaphragm operates to tilt a mercury tube switch. The diaphragm is made of material impervious to gases. The spring loading mechanism is easily adjusted by a set screw located near the top cover plate. A built-in level in the top cover makes installation comparatively simple. Operation is carried on over a pressure range of 3 to 12-inches of water and from pressure differentials of 2 to 4-inches of water.

Circle No. 35 on Postcard

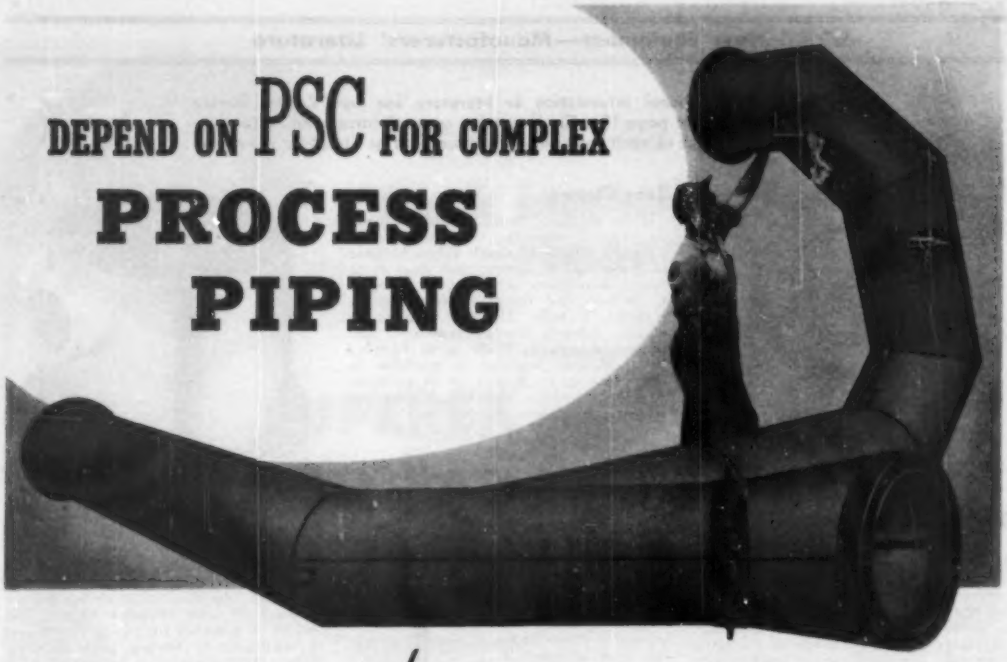


Pallet Platform

A new platform adapter for the Towmotor Electric Pallet Truck was recently made available by Towmotor Corporation. The device swiftly converts the Model "W" electric pallet truck into a platform truck, and makes possible the handling of platforms, skids and tote boxes. Constructed of sturdy steel framework, the new platform adapter adds extra height to the forks of the Towmotor Model "W." When not in use, it folds up over the battery and latches securely as shown in the photo.

Circle No. 36 on Postcard

DEPEND ON PSC FOR COMPLEX PROCESS PIPING



furnished in any SHAPE, DIAMETER or SECTION

As suppliers of welded alloy tubing to the petroleum and chemical processing industries for 25 years, The Pressed Steel Co. offers you a wealth of experience in the custom fabrication of tubing. Pictured at top is a typical example of the many complicated assemblies we are called upon to custom-fabricate. As pictured at right, we furnish tubing in any diameter up to 60", as well as in any wall thickness. PSC tubing of light gauges frequently effect large savings.

IN ANY ALLOY FOR YOUR SPECIFIC HEAT OR CORROSION PROBLEM

Furnished in any alloy, PSC tubing enables you always to use the one particular metal most suited for a specific heat or corrosion condition. And in quantities, PSC welded tubing offers impressive savings over seamless. Can be readily bent, coiled, swaged and formed; and butt-welded to make any required length. For temperatures up to 2200°F. See how our wealth of fabricating experience can help you.

PSC

THE PRESSED STEEL COMPANY

of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

To obtain additional information or literature use free Reader Service Postcard opposite page 192. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.

Tubes and Plates

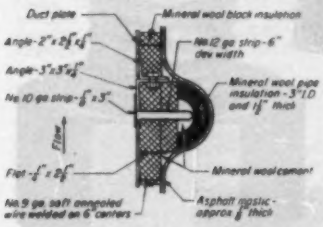
A new edition of "Anaconda Tubes and Plates for Condensers and Heat Exchangers" has been announced by the Anaconda Copper Mining Company. Aimed at engineers responsible for the selection of materials, it discusses application and installation of condenser and heat exchanger tubes, and plates for tube sheets, heads and baffles.

Circle No. 37 on Postcard

Jacks

Lifting and lowering jacks for service in oil fields and refineries is described in a bulletin by the Duff-Norton Manufacturing Company. The bulletin features the No. 1523 All-Purpose Oil Field Jack, adaptable for straight, chain, claw and foot lifting.

Circle No. 38 on Postcard


Duct plate
Mineral wool block insulation
No.12 ga. strip - 6" dov width
Mineral wool pipe insulation - 3" I.D. and 1½" thick
Flow
Mineral wool cement
Asphalt mastic - approx. ⅛" thick
No. 9 ga. soft annealed wire welded on 6" centers

Insulated Expansion Joint

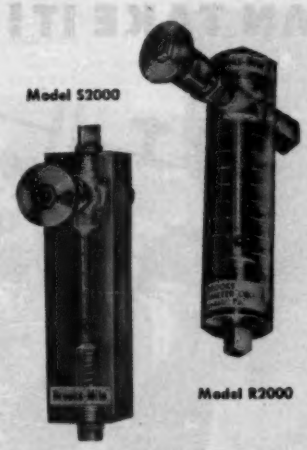
An unusual application of mineral wool pipe insulation has been developed by the Riley Stoker Corporation to insulate expansion joints on gas and air ducts. Such maintenance headaches as surface cracks and hot spots are said to be eliminated. A cross section, pictured, shows the materials and construction of the expansion joints around the entire perimeter of the duct. The actual gap in the duct plate is covered by two iron angles, welded to one side of the duct plate. As the duct expands and contracts with changes in temperature, sliding occurs between the top edge of the 10-gauge strip and the angle.

Circle No. 39 on Postcard

Centrifugal Pumps

A revised bulletin on centrifugal pumps for refinery service has been announced by Worthington Pump and Machinery Corporation and describes the types HR and HB one and two-stage volute, saddle-mounted, vertically split centrifugal pumps. Available to official company personnel only.

Circle No. 40 on Postcard



Mite Purge Meter

An acrylic plastic purge meter that eliminates packing glands and glass parts is manufactured by Brooks Rotameter Company. With a range of 0.01 to 54.0 gallons per hour of water and 0.2 to 216 cubic feet per hour of air, the purge meter indicates rate of flow by the position of a spherical float in the metering tube. This tube and all piping connections are bored from a block of acrylic plastic. Flow adjustment is made with a Flo-Mite needle control valve, which may be installed on either inlet or outlet position of the metering tube. Model R 2000 has etched reference marks for approximate flow indication, while direct flow readings are made with the Model S 2000 which has standard calibrations for either air or water.

Circle No. 41 on Postcard

Measuring System

Application of the Baldwin SR-4 fluid pressure measuring system in oil and chemical processing for automatic control, remote indicating and recording, is featured in a bulletin issued by Baldwin-Lima-Hamilton Corporation.

Circle No. 42 on Postcard

Rubber Flooring

"Immediate-Set" is an industrial floor material of asphalt-rock limestone and cold asphalt emulsion with pulverized natural rubber added. The rubber reduces brittleness in sub-freezing weather and provides greater traction when the floor surface is wet. The tendency to rut or wave even under heavy point loads is lessened because of the rubber. The formula is factory mixed and shipped in 100 pound bags by the Flash-Stone Company, Inc.

Circle No. 43 on Postcard

Packaged Heaters

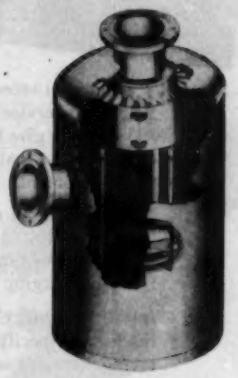
A folder describing and illustrating Edwin L. Wiegand Company's complete line of "packaged" heaters, immersion, circulation, and others with built-in controls, is available upon request.

Circle No. 44 on Postcard

Industrial Truck

Clark Equipment Company's new fork truck, the Clark Gas Clipper, has these new features: easy accessibility to the engine, new type parking brake, an instrument panel mounted on the steering column, easier steering and design providing for faster maintenance. The instrument panel is mounted for full visibility from the driver's seat. A Protecto-seal gas cap, completely outside of the engine compartment to reduce fire hazard from spilled gasoline, is recessed into the dash. Use of an Elliot-type axle with the tie rods in the same plane and more nearly in line with the forces they transmit is part of the new design which has achieved "no kick-back" steering.

Circle No. 45 on Postcard

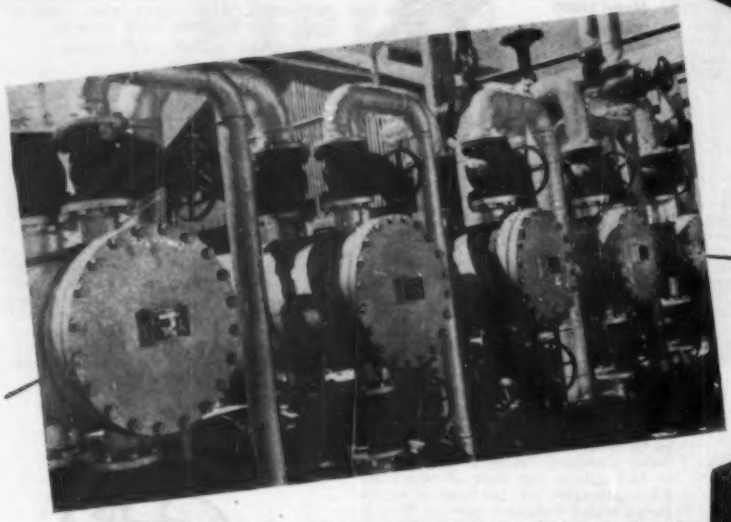


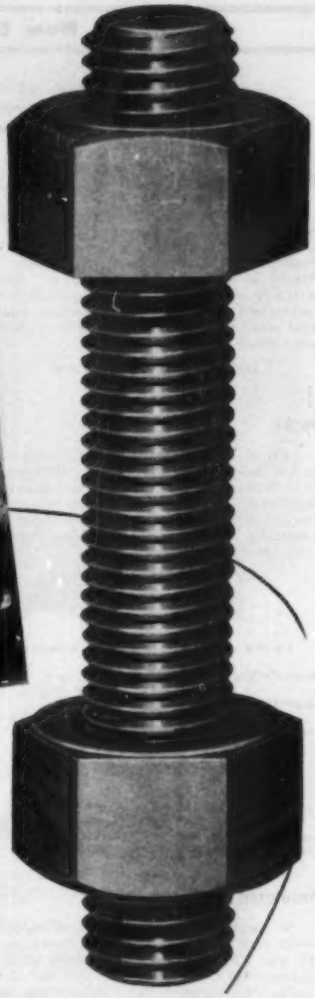
Receiver-Purifier

Destructive entrainment may be removed from vapor lines by use of the new receiver-type Purifier developed by the V. D. Anderson Company. Chief advantages claimed by the company are low initial cost, no moving parts, self-cleaning action which eliminates maintenance, fluid dynamics designing which provides for handling extreme velocities at high efficiency and reduction of pressure drop to a minimum. It is built and stamped to ASME Code for Unifred Pressure Vessels. The Purifier has forged steel flanges and welded steel body. Various nozzle arrangements meet all piping layouts, and units are made in nominal size from four to 16 inches.

Circle No. 46 on Postcard

Turn on the heat...
THIS STUD CAN TAKE IT!





REPUBLIC UPSON ALLOY STEEL STUDS are made for rough and tough service. They can take blistering, searing heat in stride and go on to give long dependable service under severe corrosion conditions . . . all the while, holding extreme high pressures in tight control.

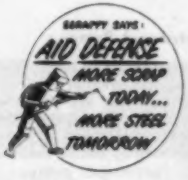
You'll find them more than a match for the most troublesome fastening job . . . easy to turn up to a tight lasting hold—and just as easy to turn off when it's necessary to retube or to open lines for purging or blowing down.

Install Republic Upson Alloy Steel Studs when replacements are needed and specify them for new equipment. It will pay off big in saving...trouble saving, time saving, saving on maintenance costs.

Made from Alloy Steel – from the furnaces of Republic, world's leading alloy steel producer.

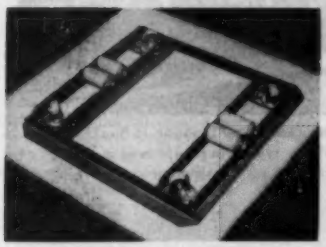
REPUBLIC STEEL CORPORATION
BOLT AND NUT DIVISION • CLEVELAND 13, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC *Upson Quality* **BOLTS AND NUTS**



Other Republic Products Include Machine, Tank and Carriage Bolts—Lag Screws, Cap Screws and Rivets

To obtain additional information or literature use free Reader Service Postcard opposite page 192. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.



Pallet Mover

Ace Swivel Pallet Rollers, manufactured by the Frank L. Robinson Company, are described in a brochure. The frame is constructed of high tensile strength steel, fully welded, and the equalizer design retains parallelism and alignment of frame under all conditions.

Circle No. 47 on Postcard

Carboy Pump

The new Carboy pump, originally designed by Dow Chemical Company and revised by Sinclair Research Laboratories, is being manufactured by Laboratory Industries, Inc. Fabricated of heavy Pyrex tubing, the unit is said to be ideal for dispensing corrosive fluids safely. Liquid density does not affect the pump operation because the positive displacement principle has been utilized in the design.

Circle No. 48 on Postcard

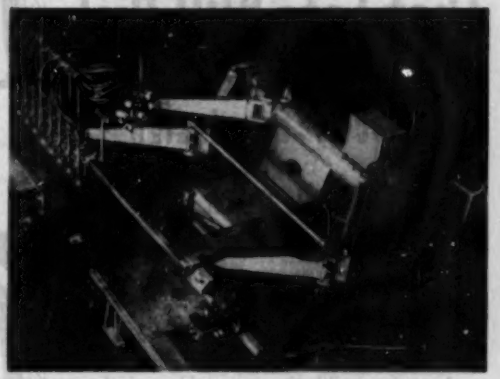
Resistant Glass

The Pfaudler Company has just announced a new acid-alkali-resisting glass which is intended for use in the pH range from 9 to 12 and at temperatures up to 212° F. Pfaudler claims the new glass has at least three times the alkali resistance of the present glass and has essentially the same acid resistance. The new glass is not intended for use with high concentrations of strong alkalis at high temperatures, but will prove useful in processes involving a neutralization reaction, where equipment is subjected to alkaline solutions at moderate temperatures.

Circle No. 49 on Postcard

Gas Cutting Machine

Guided by manual, magnetic or electronic tracer, the Airco No. 50 Travograph, developed by Air Reduction Magnolia Company, a division of Air Reduction Company, Inc., is a new heavy duty pantograph type cutting machine with built in accuracy for precision cutting. It will cut an unlimited variety of shapes from steel plates, slabs, billets and forgings and makes practicable and economical the cutting of either one or a few parts, or identical parts on a quantity production basis. The machine is of all welded, heavy gage steel construction.



Circle No. 50 on Postcard

Turbine Generator

Design and construction features of Allis-Chalmers Manufacturing Company's WA-Series steam turbine generator units manufactured in NEMA ratings of 2000 to 7500 kw. are described in a new bulletin released by the company. The series units are built in the condensing type, for power generation only, and in the non-condensing and automatic extraction types to provide a steam-power balance where process steam is used.

Circle No. 51 on Postcard

Sealing—Lube Compounds

New Parker Appliance Company catalog 5400 describes twelve different compounds for thread sealing and valve lubrication. These include general-purpose thread and gasket sealing and anti-seize compounds as well as specialized mixtures for service with aluminum parts, and for alcohol, oxygen and fuel-handling systems.

Circle No. 52 on Postcard

High Pressure Regulator

Grove Regulator Company has released a bulletin-catalog describing applications, operating principles and features of the Powreator Dome Regulators which are used extensively for controlling gas, liquids and air at pressures up to 6000 pounds at temperatures ranging to 150° F. Connection sizes range from ¼ to 2 inches. The unit derives its powerful equalizing force from the pressure loaded dome, reducing initial pressure to the desired delivered pressure. Delivery pressure is maintained automatically.

Circle No. 53 on Postcard

Cylinder Application

"Use a Cylinder and Save a Man" is the title of a bulletin released by Ledeen Manufacturing Company, manufacturers of cylinders, valves and valve actuators. The bulletin describes cylinder applications in chemical plants, oil refineries, plastics concrete plants, etc. Manual power is eliminated or reduced, according to Ledeen.

Circle No. 54 on Postcard

Fuel Strainers

The new "slip in, slip out" fuel strainers which provide finger-tip control for clean fuel deliveries have been developed by Buckeye Iron & Brass Works. The 872 Inlet Strainer is designed for permanent installation at the end of tank fill pipes in bulk plants. The Outlet Strainer, No. 872T, is for permanent coupling to the unloading pipes of tank trucks. Both have strainer cones of 14-mesh galvanized wire which permit full flow but prevent rust scale, dirt and other objects from passing through.

Circle No. 55 on Postcard

Pick The Make That Lets YOU Pick

exactly the design you need

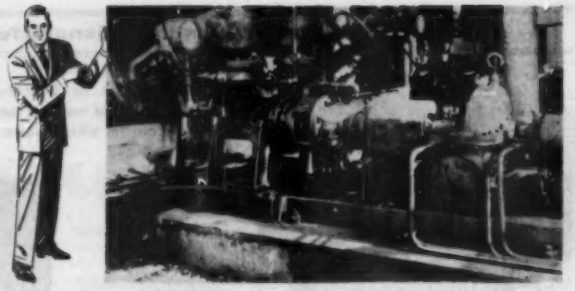
Worthington has a centrifugal pump for practically any conceivable refinery requirement—in the most complete range of sizes.

The pictures here show only a few of the many purposes served by Worthington Centrifugals. Whether your problem is high temperatures . . . volatile liquids . . . abrasives . . . acids . . . or any of the host of others that harass refineries—the Worthington line includes the one best pump for the job.

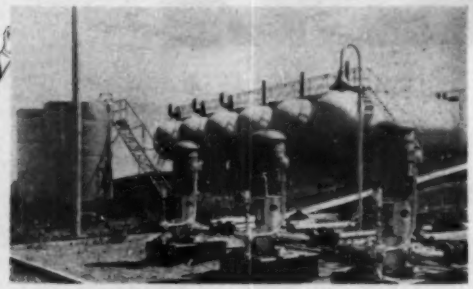
Further assurance you enjoy when you standardize on Worthington: you know that Worthington, making the broadest line of pumps, will recommend the best type for each job—you know you'll benefit from *engineering* that's the finest in the business—and you know you can depend on *service* that does its best to keep you in peak production.

Write us for bulletins on the types in which you're interested and see why *there's more worth in Worthington*. Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.

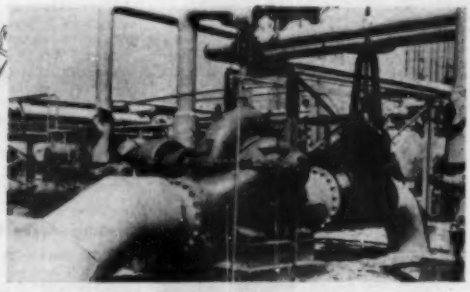
SEE OUR CATALOG IN SWEET'S



WORTHINGTON HR CENTRIFUGAL, shown at Sun Oil Co., Marcus Hook, Pa., is typical of pumps used in distillation, cracking and treating petroleum products.



WORTHINGTON QSR VERTICAL centrifugal process pump, shown at Magnolia Petroleum Company, Chitwood, Oklahoma, is used to transfer propane, butane and LPG.



WORTHINGTON LA CENTRIFUGAL, turbine-driven, shown at Carthage Corporation plant, Carthage, Texas, is typical of cooling tower and general service pumps.

THE WORLD'S BROADEST LINE ASSURES YOU THE RIGHT PUMP FOR EVERY JOB

WORTHINGTON

C.1.4

Type HR and HB. Capacities to 1600 gpm. Heads to 900 ft. Temperatures from far below zero to 800 F. Pressures from high vacuum to 750 lb. gauge.

Type HD Hydraulically-balanced, double-suction impeller handles boiling liquids with low submergence. 600 to 3200 gpm. Heads to 700 ft, temperatures to 850 F, pressures to 550 lb.

Type CNE for loading or transfer service. Capacities to 1500 gpm. Heads to 502 ft.

Type HBH Available in 12 sizes. Capacities to 700 gpm. Heads to 450 ft. Maximum temperatures 500 F.

Catalogues, New Equipment Literature

Offered in this issue's advertisements. Use postcards opposite page 192

TUBE CLEANERS, EXPANDERS, MAINTENANCE EQUIPMENT—Literature. Airetool Manufacturing Company. See page 182.
Circle A2 on postcard.

CATALYST, DEHYDRATION AGENTS—Information. Aluminum Company of America. See page 25.
Circle A4 on postcard.

HEAT TRANSFER UNITS—Catalog. American Locomotive Company. See page 21.
Circle A6 on postcard.

EXCHANGER TUBE MATERIALS, APPLICATION—Information. The American Brass Company. See page 155.
Circle A5 on postcard.

REGULATING VALVES—Bulletin. The Annin Co. See page 24.
Circle A8 on postcard.

STEAM TRAPS—Catalog. Armstrong Machine Works. See page 5.
Circle A9 on postcard.

REFRACTORIES, FIRE BRICK—Bulletin R-29. The Babcock & Wilcox Company. See page 219.
Circle B2 on postcard.

ELECTRONIC RESISTANCE THERMOMETER—Bulletin 230-C. Bailey Meter Company. See page 47.
Circle B5 on postcard.

PIPE AND CONDUIT THREADER—Bulletin 51. Beaver Pipe Tools, Inc. See page 234.
Circle B6 on postcard.

CORROSION TREATMENT—Bulletin. The Bird-Archer Company. See page 32.
Circle B10 on postcard.

STRESS RELIEVING OVEN—Data. Black, Sivalls & Bryson, Inc. See page 40.
Circle B10 on postcard.

GRATING AND STAIR TREADS—Data. Blaw-Knox Company. See page 228.
Circle C1 on postcard.

CONTROLLERS—Bulletin AI20. The Bristol Company. See page 18.
Circle C5 on postcard.

COOLING TOWER PUMP—Data. Byron Jackson Company. See page 58.
Circle C6 on postcard.

CHECK VALVES—Bulletin 30. Chapman Valve Mfg. Company. See page 41.
Circle C8 on postcard.

TOWER ESCAPE DEVICE—Folder. Charlie's Machine Works. See page 225.
Circle C9 on postcard.

STORAGE TANKS—Data. Chicago Bridge & Iron Company. See page 88.
Circle D1 on postcard.

PIPE INSULATION JACKETING—Data. Childers Manufacturing Company. See pages 92-93.
Circle D3 on postcard.

COMPRESSORS—Bulletin 118. Clark Bros. Company. See page 167.
Circle D4 on postcard.

THROTTLING CONTROLLER—Bulletin C-1. Conoflow Corporation. See page 230.
Circle D5 on postcard.

GATE VALVES—Circular 1081. Crane Company. See page 159.
Circle D8 on postcard.

STEAM JET EJECTOR—Data. Croll-Reynolds Co. See page 234.
Circle D9 on postcard.

MATERIAL HANDLING EQUIPMENT—Data. Dempster Brothers, Inc. See page 60.
Circle E2 on postcard.

SULPHUR DETERMINATOR—Data. Harry W. Dietert Co. See page 227.
Circle E3 on postcard.

ABSORPTION FILTER—Bulletin B-1 A. Dollinger Corp. See page 17.
Circle E4 on postcard.

PETROLEUM CHEMICALS—Free Displays. E. I. du Pont de Nemours & Co. See Insert 208-209.
Circle E7 on postcard.

PETROLEUM CHEMICALS—Data. E. I. du Pont de Nemours & Co. See Page 70.
Circle E6 on postcard.

SHAFT PACKING—Bulletin 174 PR. Durametallic Corp. See page 216.
Circle E9 on postcard.

ALLOY PRODUCTS — Catalog. Electric Steel Foundry. See page 51.
Circle F1 on postcard.

TUBE CLEANERS—Bulletin Y-29, Elliott Co. See page 39.
Circle F2 on postcard.

ELECTRIC MOTORS—Bulletin. Elliott Co. See page 157.
Circle F3 on postcard.

ANTI-KNOCK COMPOUND—Book. Ethyl Corp. See insert 32-33.
Circle F5 on postcard.

COOLING TOWERS—Data. The Fluor Corp. See pages 44-45.
Circle F8 on postcard.

CONTROL VALVES—Bulletin 277-2. The Foxboro Co. See page 214.
Circle F10 on postcard.

MECHANICAL SEALS—Data. The Garlock Packing Co. See page 62.
Circle G2 on postcard.

CHEMICAL COMPOUNDS — Data. General Chemical Division, Allied Chemical & Dye Corp. See page 226.
Circle G3 on postcard.

ELECTRICAL CONTROL INSTRUMENTS—Bulletins. General Electric Co. See page 207.
Circle G5 on postcard.

BUBBLE TRAYS AND CAPS—Data. Gilbert & Barker Mfg. Co. See page 63.
Circle G7 on postcard.

CASTABLE REFRACTORIES—Data. A. P. Green Fire Brick Co. See page 210.
Circle G8 on postcard.

COOLING TOWER FANS—Data. Hartzell Propeller Fan Co. See page 240.
Circle G10 on postcard.

PRESSURE SAMPLE CONTAINERS — Data. Hoke, Inc. See page 215.
Circle H1 on postcard.

COOLING EQUIPMENT—Bulletin. Hudson Engineering Corp. See page 95.
Circle H2 on postcard.

PORTABLE MIXERS—Catalog. International Engineering, Inc. See page 170.
Circle H4 on postcard.

DE-IONIZING SYSTEMS — Data. International Nickel Co. See page 20.
Circle H3 on postcard.

NICKEL ALLOY IRONS—Booklet. The International Nickel Co. See page 181.
Circle H6 on postcard.

WIRE MESH—Data. The C. O. Jelliff Mfg. Corp. See page 216.
Circle H7 on postcard.

HEAT EXCHANGER GASKETS—Data. Johns-Manville Co. See page 22.
Circle H8 on postcard.

BLOCK INSULATION—Data. Johns-Manville Co. See page 196.
Circle H9 on postcard.

HEAT INSULATION — Data. Kaylo Division, Owens-Illinois Glass Co. See page 56.
Circle H10 on postcard.

PIPE AND HEATER INSULATION — Data. Keasbey & Mattison Co. See page 16.
Circle J1 on postcard.

FRACTIONATING TRAYS—Bulletin No. 629. The Koch Engineering Co. See page 164.
Circle J3 on postcard.

WATER WELL SYSTEMS—Catalog. Layne & Bowler, Inc. See page 237.
Circle J4 on postcard.

RECORDING INSTRUMENTS—Data. Leeds & Northrup Co. See page 8.
Circle J5 on postcard.

WATER REMOVAL FROM PRODUCT STREAMS—Bulletin. Warner Lewis Co. See page 232.
Circle J6 on postcard.

LOADING ARM ASSEMBLY—Data. A. Y. McDonald Mfg. Co. See IV Cover.
Circle K3 on postcard.

MIST ELIMINATORS—Brochure. Metal Textile Corp. See page 218.
Circle K6 on postcard.

CONTROLLERS, RECORDERS, INDICATORS—Data. Minneapolis-Honeywell Regulator Co. See pages 48-49.
Circle K7 on postcard.

MIXERS—Literature. Mixing Equipment Co. See page 74.
Circle K8 on postcard.

SLUDGE RECOVERY UNIT—Data. Monsanto Chemical Co. See page 35.
Circle K9 on postcard.

CUTTING OIL ADDITIVE — Data. Monsanto Chemical Co. See page 233.
Circle K10 on postcard.

HEAT INSULATION—Data Manual. Mundet Cork Corp. See page 178.
Circle L2 on postcard.

STEAM TURBINES—Data. Murray Iron Works Co. See page 209.
Circle L3 on postcard.

PROTECTIVE COATINGS—Data. The Natasco Co. See page 190.
Circle L4 on postcard.

OIL-GAS COMBUSTION UNITS—Data. National Airoil Burner Co. See page 208.
Circle L5 on postcard.

CRACKING CATALYSTS—Data. National Aluminate Corp. See page 9.
Circle L6 on postcard.

SCALE AND RUST REMOVER—Booklet. Oakite Products, Inc. See page 236.
Circle M3 on postcard.

VALVE OPERATORS—Catalog L-50. Philadelphia Gear Works, Inc. See page 46.
Circle M8 on postcard.

BAR STOCK VALVES—Data. Reading, Pratt & Cady Division, American Chain & Cable Co. See page 176.
Circle N5 on postcard.

HEAT EXCHANGER AND CONDENSER TUBES—Data. Republic Steel Corp. See page 31.
Circle N7 on postcard.

PREFABRICATED INSULATED PIPING—Data. The Ric-Wil Co. See page 174.
Circle N10 on postcard.

DIAL THERMOMETER—Data. Rochester Mfg. Co. See page 216.
Circle P1 on postcard.

BALL VALVES—Data. Rockwood Sprinkler Co. See page Opp. 17.
Circle P2 on postcard.

INERT GAS GENERATORS—Data. Roots-Connersville Blower Corp. See page 166.
Circle P3 on postcard.

CONDENSER TUBES — Booklet. Scovill Mfg. Company. See page 65.
Circle P4 on postcard.

SEALING UNIT—Data. Sealol Corp. See page 236.
Circle P5 on postcard.

HEATERS—Booklet. Selas Corp. of Amerita. See page 42.
Circle P6 on postcard.

FUEL OIL ADDITIVES—Data. Shell Chemical Corp. See page 25.
Circle P8 on postcard.

SCREW PUMPS—Data. Sier-Bath Gear & Pump Co. See page 225.
Circle P9 on postcard.

PUMP VALVES—Catalog. Sims Pump Valve Co. See page 211.
Circle P10 on postcard.

SAFETY GRATING—Data. A. O. Smith Corp. See page 227.
Circle Q2 on postcard.

DIRECT FIRED HEATERS — Bulletin B-45. Struthers Wells Corp. See page 43.
Circle Q4 on postcard.

REFINERY AND GASOLINE PLANT EQUIPMENT—Data. Superior Manufacturing Co. See page 234.
Circle Q6 on postcard.

PRESSURE VESSEL OUTLETS—Catalog No. 501. Taylor Forge & Pipe Works. See page 57.
Circle Q7 on postcard.

GASOLINE ADDITIVES — Data and Samples. Tennessee Eastman Co. See page 229.
Circle Q9 on postcard.

STEAM TURBINES—Bulletin S-116. The Terry Steam Turbine Co. See page 67.
Circle Q10 on postcard.

SPIRAL WOUND GASKETS — Data. United States Gasket Co. See page 184.
Circle R3 on postcard.

TANK VENTING EQUIPMENT — Bulletin CP-2001. The Vapor Recovery Systems Co. See page 50.
Circle R4 on postcard.

OIL TREATING COMPOUND — Data. Visco Products Co. See page 55.
Circle R5 on postcard.

HEAT EXCHANGERS — Bulletin PE-1. Henry Vogt Machine Co. See page 204.
Circle R6 on postcard.

CHLORINATORS — Data. Wallace & Tiernan Products, Inc. See page 213.
Circle R8 on postcard.

GLOBE VALVES—Data. Walworth Co. See page 194.
Circle R9 on postcard.

FORGED PIPE FITTINGS — Bulletins. Watson-Stillman Co. See page 183.
Circle S1 on postcard.

STEAM TURBINES—Data. Whiton Machine Co. See page 173.
Circle S4 on postcard.

HEAT EXCHANGER TUBES—Bulletin. Wolverine Tube Division, Calumet & Hecla Consolidated Copper Co. See page 231.
Circle S5 on postcard.

Keep Heat Transfer Surfaces CLEAN...

SPECIFY

Vogt

SCRAPED SURFACE *Exchangers*

IF you are all "gummed up" with a tough heat transfer problem, Vogt Scraped Surface Exchangers will provide the answer. They have patented scraper elements which prevent fouling of the heat transfer surfaces and insure the highest rate of heat exchange between the product and the cooling or heating medium. The scrapers also continuously agitate the fluid and assist removal of solids from the unit.

DOUBLE PIPE EQUIPMENT is available in two types; EXCHANGERS, for cooling with water, brine, and cold filtrate, and for heating with steam or hot liquids; and CHILLERS, for use with volatile refrigerants such as ammonia, propane, and Freon. Both types have 8" jacket pipes and 6" inner pipes with scrapers.

SHELL AND PIPE TYPE UNITS are designed for use with volatile refrigerants and for heating fluids with steam or similar heating mediums. They consist of large welded shells each containing seven 6" scraped pipe sections.

Vogt Scraped Surface Exchangers serve profitably as oil chillers, crystallizers, and heaters in many processes in the petroleum and chemical industries. Their application to your heat transfer problems will receive the prompt attention of our Engineering staff.

Write for Bulletin PE-1

*DOUBLE PIPE UNIT. Drive end close-up of 12 section unit under test in our shop.

*SHELL and PIPE UNITS. Two of five units installed in a leading petroleum refinery.

*Patented

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

Branch Offices:

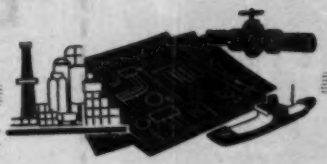
NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO

ST. LOUIS • DALLAS • CHARLESTON, W. VA.

Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by DR. HEINZ HEINEMANN

(From the Official Gazette, September 18, 25 and October 2, 9, 1951.)



REFINING

U.S.P. 2,568,115-7. Processes of Breaking Petroleum Emulsions, M. DeGroote and B. Keiser to Petrolite Corporation, Ltd.

Details are claimed of processes for breaking petroleum emulsions of the water-in-oil type by means of demulsifiers including hydrophile synthetic products of complex combinations.

U.S.P. 2,568,517. Extraction of Organic Oxygenated Compounds from Hydrocarbon Mixtures, L. G. Sharp and D. R. Carmody to Stanolind Oil & Gas Company.

In the separation of hydrocarbons from alcohols, aldehydes and/or ketones dissolved in the hydrocarbons, the solution is extracted with an aqueous solution of a bisulfite compound, such as sodium bisulfite, and a mixture of fatty acid soaps. The extractant solution shall have a pH of 6.7-9.0. The extract phase containing all or part of the oxygenated compounds, has an increased oxygenated compound to hydrocarbon ratio.

U.S.P. 2,568,717. Separation of Organic Compounds. W. P. Burton and H. G. McGrath to The M. W. Kellogg Company.

In the separation of the oxygenated and non-oxygenated products of the catalytic hydrogenation of carbon oxides with formation of an oil-product liquid phase and a water-product liquid phase, the oil-product phase is treated with alkali to convert organic acids to their salts which are separated and further treated.

U.S.P. 2,568,738. Process for Resolving Emulsions. W. H. Kirkpatrick and D. L. Wilson to Visco Products Company.

Water-in-oil emulsions are resolved by means of a condensation product of a certain type of a modified alkylolamine and a certain type of a detergent forming body.

U.S.P. 2,568,739. Process for Resolving Emulsions. W. H. Kirkpatrick and E. T. Kocher to Visco Products Company.

Water-in-oil emulsions are broken by means of a water-wettable modified alkyd resin of specified structure.

U.S.P. 2,568,740. Demulsifying Compositions. W. H. Kirkpatrick and D. L. Wilson to Visco Products Company.

A demulsifier for water-in-oil emulsions consists of specified amounts of a surface active, sub-resinous water wettable colloid, a hydrophilic un-ionized colloid, water, and a gel liquefying agent for the hydrophilic colloid.

U.S.P. 2,568,741. Process and Compositions for Resolving Petroleum Emulsions. W. H. Kirkpatrick and E. T. Kocher to Visco Products Company.

A water-in-oil emulsion is broken by means of a modified resin derived from the reaction of a blown tall oil, an alkylolamine, an acidic salt of a metal forming an amphoteric hydroxide, and a mixed ester of certain characteristics.

U.S.P. 2,568,742. Chemical Demulsifying Composition and Demulsification Method. W. H. Kirkpatrick to Visco Products Company.

An oil-in-water emulsion is resolved by treatment with a composition comprising a molecularly dehydrated condensation product of 3-10 percent $ZnCl_2$ with an alkylolamine, intimately dispersed with hydrophylic unionized colloid in a mutual solvent.

U.S.P. 2,568,743. Process for Resolving Emulsions. W. H. Kirkpatrick to Visco Products Company.

Water-in-oil emulsions are broken by means of a condensation product of an alkanolamine and a mixture of at least two dissimilar unsaturated carboxylic acids of special characteristics.

U.S.P. 2,568,744. Demulsification Process and Composition. E. T. Kocher to Visco Products Company.

An oil-in-water emulsion is resolved by a reaction product similar to that employed in U.S.P. 2,568,742.

U.S.P. 2,568,745. Demulsifying Composition and Process for Breaking an Oil-in-Water Emulsion. W. H. Kirkpatrick to Visco Products Company.

The process of this patent is closely related to that of U.S.P. 2,568,744.

U.S.P. 2,568,746. Emulsion Breaking. W. H. Kirkpatrick and D. L. Wilson to Visco Products Company.

Water-in-oil emulsions are broken by an alkenyl succinic acid, its esters or certain of its salts. The alkenyl group of the compound may contain 5-30 C atoms.

U.S.P. 2,568,748. Compositions and Process for Resolving Emulsions. W. H. Kirkpatrick and D. L. Wilson to Visco Products Company.

The process according to this patent is closely related to that of U.S.P. 2,568,738.

U.S.P. 2,569,216. Separation of Olefins from Hydrocarbon Distillates Containing Aromatics. E. Arundale to Standard Oil Development Company.

Aromatic hydrocarbons with 6-8 C atoms and containing olefins of the same boiling range as the aromatics are contacted at a temperature of 20-50° C. with 5-25 percent by volume of a treating agent consisting of H_2SO_4 of 50-80 percent concentration and formaldehyde or acetaldehyde of specified concentration. In subsequent distillation, the aromatic hydrocarbons are removed overhead and separated from the olefins.

U.S.P. 2,569,384-5. Recovery of Oxygenated Compounds from Hydrocarbon Oils. C. E. Morrell and J. H. McAteer to Standard Oil Development Company.

Aliphatic alcohols, aldehydes, ketones, esters and acetals are separated from their mixture with acidic oxygenated compounds and hydrocarbons by selective extraction with a 2-10 percent acetic acid aqueous solution at a temperature between the freezing point of the solvent and 125° C. The extract phase formed comprises the neutral oxygenated compounds, while the raffinate phase comprises the hydrocarbons and acidic oxygenated compounds.

The same extractant or a corresponding solution of another aliphatic carboxylic acid with less than five C atoms can also be used for the recovery of oxygenated organic compounds from their mixture with hydrocarbons as obtained in a Fischer-Tropsch synthesis.

U.S.P. 2,569,429. Synthetic Lubricants. T. F. Rutledge, F. M. Seger, A. N. Sachanen and W. E. Garwood to Socony-Vacuum Oil Company, Inc.

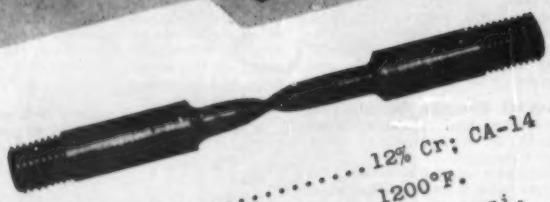
An olefinic charge stock obtained by a Fischer-Tropsch reaction and having a substantial portion boiling between 150-600° F. is contacted with a saturated solution of an alkali metal salt of a monohydroxy aromatic compound of the formula R_n-A-OH wherein A is an aromatic nucleus, R is an alkyl group of less than six C atoms, and n is an integer from 0-3. The extract and raffinate layers formed are separated, the former being enriched in organic oxygenated compounds and the latter in olefins. The separated raffinate layer may be employed for the production of a synthetic lubricant.

U.S.P. 2,569,984 and 2,569,986. Extractive Crystallization Process. L. C. Fetterly to Shell Development Company.

Straight-chain hydrocarbons are separated from their mixture with other hydrocarbons boiling within the gasoline and lubricating oil range by treating the

The Story of a Test

DURALOY



Test Rod.....12% Cr; CA-14
Test Temperature.....1200°F.
Tensile Strength.....38,200 psi.
Elongation (2")..... 29.5%
Reduction in Area..... 86.1%

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Patents

liquid mixture at a temperature below 100° F. with an aqueous solution of urea in the presence of methyl isobutyl ketone. Crystalline molecular complexes of urea and straight-chain hydrocarbons are formed, which are separated.

Instead of using methyl isobutyl ketone, an aliphatic monohydric alcohol with 4-6 C atoms may be employed, and instead of urea thiourea can be used.

U.S.P. 2,570,044. Propane Fractionation of Reduced Crude Oil with Recycle of a Solvent Extraction. B. C. Benedict and W. N. Axe to Phillips Petroleum Company.

Details are claimed for recovering a lubricating oil fraction from a low asphalt-content crude lubricating oil stock by propane.

U.S.P. 2,570,066. Extractive Distillation Process. M. R. Morrow and J. W. Smalling to Standard Oil Development Company.

A vaporized mixture of a naphthene and a paraffin boiling in the gasoline range and having a boiling range no greater than 50° F. is countercurrently contacted with tetra-methylbenzene at a temperature above the boiling range of the mixture. A raffinate phase including the paraffin and an extract phase comprising the naphthalene and the extractant are formed and separated.

U.S.P. 2,570,377. Fuel Compositions. A. J. Revukas to The Water Associated Oil Company.

A petroleum distillate contains a small amount of a compound of the formula

wherein R^1 and R^2 are aliphatic groups having a sum of more than 6 C atoms, R^3 is hydrogen, an alkyl, aryl, aralkyl, or alkaryl radical, and A is a phenol at least one nuclear hydrogen of which is replaced by a hydrocarbon group. The additive suppresses the tendency of the fuel to emulsify.

U.S.P. 2,570,607. Vacuum Distillation of Reduced Crude. R. B. Smith to Sinclair Refining Company.

A reduced crude stock is heated in the liquid phase under increased pressure to a temperature of about 900° F. to effect incipient cracking. The treated stock is passed to a small flash zone. Fixed gases are removed while the stock is maintained in the liquid phase under increased pressure. The heated stock is then flashed in an enlarged vacuum zone at 750-800° F. under 150-350 mm. Hg. Vaporized gas oil is removed overhead from this zone. Gas oil cracking stocks are obtained.

U.S.P. 2,570,611. Process for Breaking Petroleum Emulsions. R. W. Towne to Monsanto Chemical Company.

Petroleum emulsions of the water-in-oil type are broken by trichloroacetic acid or its alkali metal or alkaline earth metal salts.

U.S.P. 2,570,925. Method of Catalytic Dehydrofluorination. J. F. Eberle to Phillips Petroleum Company.

Organically combined fluorine is removed from hydrocarbon material by treatment with a defluorinating catalyst comprising an intimate mixture of a metal below Mg in the electromotive force series, such as Al, with a relatively

New Resistance Thermometers Accurately Indicate and Control Low Temperatures

G-E Pyrometer Equipment Quick and Easy to Inspect, Maintain

Routine inspections of new General Electric Type HP pyrometers can quickly be made. Besides making preventative maintenance easy, this equipment has many other features to provide accurate indication and temperature control of furnaces, ovens kilns, and other industrial heating equipment.

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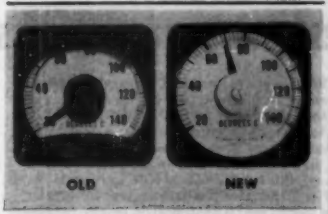


New Shadow-proof Temperature Indicators Are Easier to Read

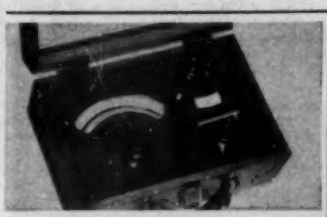
Temperatures from −100 F to +300 F can now be accurately indicated and controlled with General Electric's new line of temperature indicators. These instruments can be read from almost any angle. The dial is set forward, flush with the front of the case. A protruding convex-type glass front provides clear illumination. No more cover overhang; no more shadows caused by overhead lighting. Two sizes available—4½- and 8¾-inches. Check coupon.

TEMPERATURES FROM −100F to +300 F can now be accurately indicated and controlled with General Electric's new line of resistance thermometers. They indicate accurately within ¾ of 1 per cent full scale. Any change in temperature equivalent to 1/10 of 1 per cent full scale starts immediate control action.

Normal changes in humidity or room temperature do not affect the exactness of control. Neither does a change in control voltage. Sturdy, simple construction assures reliable operation under severe operating conditions.

NARROW TEMPERATURE SPANS, as small as 90 degrees, are available anywhere in the −100 F to +300 F range. You can buy four types of resistance thermometers—indicators, protectors, and two- or three-position controllers—for either flush or surface mounting.

For complete information, mail the coupon below.



THERMOCOUPLE POTENTIOMETER measures temperature in locations inaccessible to glass-stem thermometers. Any number of different readings can be taken in rapid succession and accurate within ±0.2% of full scale.

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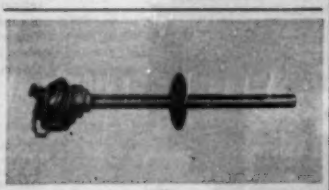
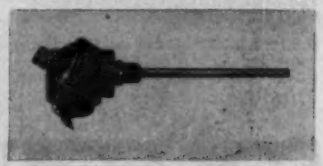


THERMOCOUPLES, COMPONENTS, AND ACCESSORIES for your pyrometer installations include protecting tubes and wells, thermocouple wire, ceramic insulators, extension wire, connectors, heads, selector switches. Send coupon today for catalog to help you obtain proper thermocouple assemblies.

Resistance Bulbs Accurate Within ±1 F between −100 F and +300 F



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- ☐ Thermocouples, Accessories (GEC-714)
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GENERAL ELECTRIC

Patents

non-volatile anhydride of a strong inorganic acid, such as phosphoric acid.

U.S.P. 2,570,990. Fuel Compositions and their Preparation. J. A. Southern, L. J. Roth, F. J. Licata, and J. Cunder to the U. S. Secretary of War.

A stable incendiar gel is formed from a volatile hydrocarbon fuel and a soap-like gelling agent comprising 50-75 percent by weight of aluminum oleate, 25-50 percent aluminum sterate, about one percent of an oxy-aromatic anti-oxidant, and 4-10 percent of a sodium oleate-sodium stearate soap.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,568,092. Phosphoric Acid or Metal Phosphate Catalysts on Pre-calcined Carriers and Their Preparation. R. F. Deering to Union Oil Company of California.

A siliceous catalyst support is calcined to a temperature of 800-1400° C. to impart physical strength thereto, and is then impregnated with an oxygen containing phosphoric acid or salts thereof with metals of the transitional groups. The dried catalyst obtained is useful in hydration and polymerization reactions.

U.S.P. 2,568,209. Oxygen-BF_3-Hydrocarbon Complex Catalyst. R. C. Wackher and C. B. Linn to Universal Oil Products Company.

The solid reaction product of oxygen, BF_3, and a hydrocarbon, such as pentane, obtained at a temperature above 150° C. and forming a complex, is found to be a useful catalyst for hydrocarbon conversions.

U.S.P. 2,568,352. Preparation of Catalyst Gel Beads by Emulsifying. W. O. Milligan to Houdry Process Corporation.

An inorganic aqueous sol is emulsified in a water-immiscible liquid. The emulsion is agitated until the solution sets as a multitude of hydrogel pieces. The hydrogel is separated from the water-immiscible liquid, purified and dried.

U.S.P. 2,570,058. Preparation of Magnesia Gels. E. A. Hunter to Standard Oil Development Company.

Magnesium alcoholates, useful in the preparation of magnesia gel catalysts by hydrolyzation, are prepared by reacting magnesium metal with an alkanol containing at least four C atoms in the presence of $CHCl_3$ or CCl_4, a hydrocarbon diluent, and a mercury compound catalyst.

U.S.P. 2,570,882. Preparation of Sintered Cobalt Oxide Pelleted Catalyst. A. B. Stiles to E. I. du Pont de Nemours & Company.

Details are claimed of a process for the preparation of sintered cobalt oxide pelleted catalyst in a state of oxidation lower than Co_3O_4 and having a crushing strength of about 4200 psi. by precipitating basic cobalt carbonate from a cobalt nitrate solution and ammonium carbonate and further treatment of the precipitate.

U.S.P. 2,570,974. Dehydration of Petroleum Hydrocarbons. F. C. Neuhart to Phillips Petroleum Company.

The regeneration by a special method is claimed of a moisture laden solid desiccant as employed, for example, in the dehydration of petroleum hydrocarbons.

CRACKING AND REFORMING

U.S.P 2,568,351. Process for Making Fuel Gas from Natural Gasoline and Straight Run Gasoline. C. G. Milbourne to Surface Combustion Corporation.

A straight run gasoline or natural gasoline of specific characteristic is separated by fractional distillation into (1) a portion comprising hydrocarbons lighter than C_4 (2) a portion comprising C_4-C_6 hydrocarbons, and (3) a portion comprising hydrocarbons heavier than C_6. Portion (2) is catalytically cracked with air, steam, or mixtures thereof to produce a product gas rich in H_2 and CO. Portion (1) is directly passed from the distillation zone into the product gas at a point adjacent the outlet of the cracking zone to enrich this product gas.

U.S.P. 2,568,967. Cracking Process. W. C. Offutt and M. C. Fogle to Gulf Research & Development Comany.

Cracking of a heavy petroleum hydrocarbon fraction containing residual components is effected to obtain gasoline without preliminary separation of said

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Call it 10,000 hours, 417 days, 60 weeks or 13 months, but remember . . . it's an average "on stream" run . . . without shutdown . . . for NATIONAL AIROIL oil-gas Tandem Combustion Units. Long runs being economically essential in the operation of a modern refinery, and extra long runs (to over 10,000 hours) are assured with NATIONAL AIROIL Tandem Units. You will realize higher profits from your oil heaters when you specify NATIONAL AIROIL oil-gas Tandem Combustion Units.

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OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes: STEAM ATOMIZING OIL BURNERS; MOTOR-DRIVEN ROTARY OIL BURNERS; MECHANICAL PRESSURE ATOMIZING OIL BURNERS; LOW AIR PRESSURE OIL BURNERS; GAS BURNERS; COMBINATION GAS and OIL BURNERS; AUTOMATIC OIL BURNERS, for small process furnaces and heating plants; FUEL OIL HEATERS; FUEL OIL PUMPING and HEATING UNITS; FURNACE RELIEF DOORS; AIR INTAKE DOORS; OBSERVATION PORTS; SPECIAL REFRACTORY SHAPES.

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DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

December ★ One of a Series of Interest to the Petroleum Industry ★ 1951

Season's Greetings

to the

PETROLEUM INDUSTRY

PETROLEUM CHEMICALS DIVISION

Special Du Pont Paper Helps Seismic Prospectors Get Better Records

Oil prospectors want seismograph charts that point up the facts clearly and quickly . . . charts that are always easy to read and interpret.

Du Pont Seismograph Paper is specially made to help prospecting crews get better charts. It is a fast, high contrast recording paper with exceptionally wide latitude to permit rapid, easy processing at high temperatures, without loss of quality. And it is made to stand up under the tough, widely varying field conditions met by seismograph crews.

The paper is available in 50 to 200 foot rolls, in a wide range of widths.

Petroleum Chemicals District Office Managers Coordinate Many Du Pont Services to Help Refiners

BOTH BY nature and necessity, the typical Du Pont Petroleum Chemicals Division District Office Manager is a versatile individual.

He is required to know the answers to many questions. His desk is a limitless well of useful information for petroleum refiners and marketers. While very few oil men know him personally, he is always alert to their problems, always ready to coordinate the facilities of the Du Pont Company into helpful services for the Petroleum Industry.

WALTER MANSBERGER, office manager of the Gulf Coast District, handles many requests for service to refiners every day. He is one of the five Du Pont Petroleum Chemicals Division district office managers engaged in this work.

In much the same way as a control tower operator keeps traffic flowing smoothly at a busy airport, the District Office Manager coordinates the field work of Du Pont sales-service representatives. He knows where each man is working every day. And he is able to channel requests for technical assistance to the right man immediately . . . and switch men *en route* if the situation requires.

A comprehensive understanding of refinery problems is part of his job. To enable a representative to be most helpful at a tank cleaning, for example, the office manager must first get all the facts concerning the job . . . such information as tank size, repairs needed, and whether it is necessary to have the tank declared "lead-free."

THE "ANSWER MAN"! Answering questions on Du Pont products is sometimes like conducting an "Information Please" program—with the office manager as the genial MC. The questions concern everything from tank car deliveries to technical data of the most elaborate sort.

Although not necessarily an engineer or chemist, the office manager can always find the answer to the most technical question — by contacting the Du Pont Petroleum Laboratory, a district laboratory, the Chambers Works, or any of the many other Du Pont sources. He can also arrange to have a Du Pont specialist come to your plant to discuss specific problems. And in addition to petroleum chemicals, he frequently handles and properly channels requests for information on neoprene, explosives for seismic explorations, and many other Du Pont products used in the petroleum industry.

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Office Manager*

MARKETING AIDS, TOO! Suppose a refiner desires to put on a dealer training meeting, or a demonstration for large fleet customers. Again, the Du Pont District Office Manager can be of help.

He will furnish an entertaining movie—booklets on gasoline quality—speakers and other promotion aids . . . with a highly instrumented Du Pont Test Fleet car, too, if that seems desirable. One of his "side lines" is helping to set up displays and demonstrations for schools and civic groups.

Everyone has heard that old adage, "When you want to get something done, ask a busy man." The next time Du Pont can be of service to *you*, just remember that the Petroleum Chemicals District Office Manager is *your* "busy man."

"The Customer Votes Every Day" Public Relations Man Stresses

HAROLD BRAYMAN, Director of Du Pont public relations, speaking at the Atlantic City NPA meeting, said: "By purchasing products or services of his own selection, the customer votes on business every day.

"These votes make big business big—yet the public constantly falls prey to the idea that bigness should be destroyed."

How can business overcome this malicious political idea?

"Most successful sales and promotional campaigns," Mr. Brayman continued, "are based on personal contact. Therefore, if business is going to win public understanding, it must take its fight right down to the small circle of contact surrounding a company's employees, stockholders, customers, neighbors and friends.

"If each company would make a real effort to tell the facts to those within sound of its own voice, I think we would be well on our way to better understanding.

"Once understanding is gained in each of these small circles of influence, the over-all effect will be such that business need fear no attack . . . because political groups are as sensitive to public opinion as business is to market votes," Mr. Brayman concluded.

Display Made For Oil Progress Week Available to Refiners For Showings

Five identical displays made for use by Du Pont Petroleum Chemicals Division district offices during Oil Progress Week are available to oil companies for special occasions.

The displays point out to the general public that petroleum is the source of many Du Pont products. These products in turn are fabricated by other manufacturers into consumer goods that benefit millions of people.

Each of the displays is made up of three panels. When assembled as a unit the display is 10 feet long and 5 feet high. It can be set up on legs to stand on the floor, or be shown without legs for window use.

The two side panels are demountable, as are the four product panels on each of them. This provides a flexibility that permits the display to be used in either large or small spaces.

Overhead lights are provided with the display and complete instructions for setting it up are included. Two men can erect the piece in eight minutes.

The nearest Du Pont Petroleum Chemicals Division district office will make the display available to oil companies on request.

"Pipeline on Wheels" A Public Relations Hit

Since the first public showing of "Pipeline on Wheels" at the Atlantic City NPA meeting in September, more than 100 prints of this new Du Pont color movie have been put into circulation.

The picture is designed to help oil companies prove to public officials, civic organizations and motorists that tank trucks for transporting gasoline are not the dangerous highway safety hazard which some people consider them to be . . . and that they are important to modern, motorized civilization.

The great number of requests for prints indicates an enthusiastic acceptance among oil men. Prints are loaned or sold to oil companies interested in using the film in their own training or public relations programs.

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A-2699

Printed in U. S. A.

components under special conditions claimed in detail.

ALKYLATION

U.S.P. 2,569,400. Alkylation of Polystyrene Using a Hydrogen Fluoride Catalyst. J. M. Butler to Monsanto Chemical Company.

Polystyrene is alkylated with an olefin in the presence of HF.

U.S.P. 2,570,263. Production of Beta-Ethyl-Naphthalene. J. E. Nickels and W. M. Kutz to Koppers Company, Inc.

A mixture of naphthalene and ethylene is heated in contact with a silica-alumina catalyst at an alkylating temperature above 275° C. (preferably at 275-350° C.) until an alkylate containing at least three parts of beta-ethyl naphthalene for each part of the alpha isomer is obtained. A portion of the beta isomer is separated from the reaction effluent, preferably by cooling with formation of crystals of the beta isomer, while the remainder of the ethyl naphthalenes is recycled.

U.S.P. 2,570,407. Reactions Involving the Use of Hydrogen Halides. J. D. Upham to Phillips Petroleum Company.

Details are claimed of a process for the preparation of a pure alkylate from a mixture of two olefins of different reactivities toward halogen halides, such as production of diisopropyl alkylate from a mixture of ethylene and propylene, by means of a predetermined controlled quantity of hydrogen halide to react with the more reactive olefin.

U.S.P. 2,570,542. Phosphoric Acid Catalyzed Thiophene Alkylation and Gravity Separation of Resultant Products. C. F. Gerald and G. R. Donaldson to Universal Oil Products Co.

Details are claimed in a process for the alkylation of thiophene compounds in the presence of an 85 percent phosphoric acid.

U.S.P. 2,570,574. Production of 2,3-Dimethylalkanes. C. B. Linn to Universal Oil Products Company.

Isobutane is alkylated with a straight-chain normally liquid 1-alkene in the presence of substantially anhydrous HF at a temperature of -10° to -50° C. 2,3-dimethylalkane is produced.

POLYMERIZATION AND CONVERSION

U.S.P. 2,567,916. Method of Making Dipentene and Vinylcyclohexene Resin. S. G. Burroughs to Pennsylvania Industrial Chemical Corporation.

A mixture of 1-vinyl cyclohexene-3 (cyclic dimer of butadiene) and commercial dipentene is reacted with an acid-reacting metal halide catalyst in the presence of a solvent diluent inert for the polymers. Hard resin polymers are formed in solution.

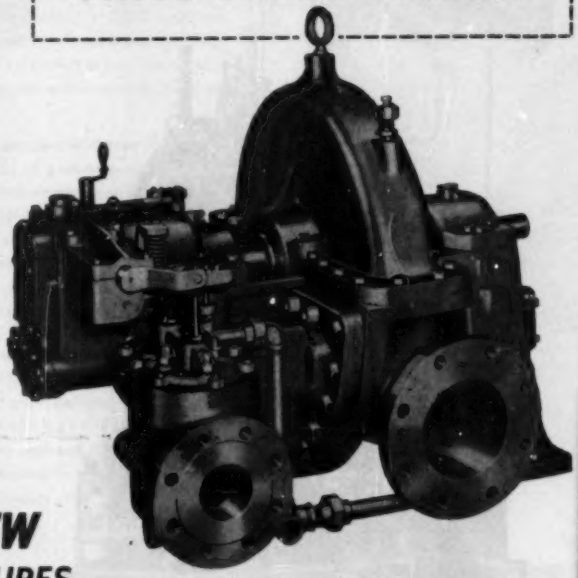
U.S.P. 2,567,917. Method of Making Beta-Pinene, Rearranged Alpha-Pinene, and Vinyl Cyclohexene Resin. S. G. Burroughs to Pennsylvania Industrial Chemical Corporation.

NEW!

MURRAY

TYPE H

MECHANICAL DRIVE SINGLE STAGE STEAM TURBINE



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Combining a host of new improvements plus time tested features, the Murray Type H offers extra-value in a medium size machine. With a range of 50-200 H.P., depending upon speed and steam conditions, it is offered with either a 16" or 20" diameter wheel. 3" or 4" steam inlet sizes available. Steam conditions up to 600 lbs., 750° and back pressures up to 150 lbs. can be used.

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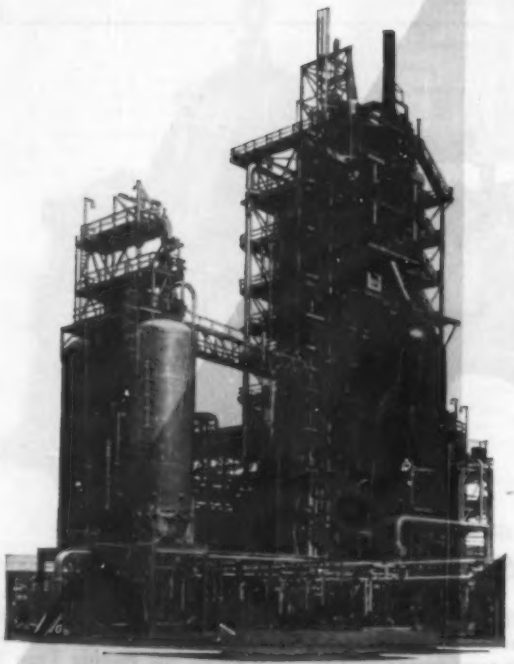
in the Regenerator of its Cat Cracking Unit



SK-7 and KS-4 were used to form a compact monolithic lining in the regenerator of this cat cracking unit at Billings, Montana. In operation over two years . . . it is giving excellent service.

SK-7 and KS-4 offer 4 Outstanding Advantages . . .

1. Cuts construction time and labor costs.
2. Reduces rebound loss.
3. Is adaptable to a variety of installations.
4. Results in linings with balanced characteristics of poured castables.

A. P. Green SK-7 and KS-4 are two great new castable refractories, offering all the advantages of ordinary castables and, in addition, may be "gunned" in place by means of a cement gun. This fast, simple method of installation lowers construction and maintenance costs.

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related to that of U.S.P. 2,567,916. The dipentene is here replaced by a terpene blend of beta-pinene and "rearranged alpha-pinene". $AlCl_3$ and $AlBr_3$ are employed as catalysts.

U.S.P. 2,567,918. Alpha-Pinene and Vinyl Cyclohexene Resin. S. G. Burroughs to Pennsylvania Industrial Chemical Corporation.

The process of this patent differs from that of U.S.P. 2,567,916 essentially in that the dipentene is replaced by alpha-pinene.

U.S.P. 2,567,919. Method of Making Beta-Pinene and Vinyl Cyclohexene Resin. S. G. Burroughs to Pennsylvania Industrial Chemical Corporation.

In the process according to this patent the alpha-pinene of USP 2,567,918 is replaced by beta-pinene.

U.S.P. 2,567,959. Fluidized Bed Evaporator and Method. J. C. Munday to Standard Oil Development Company.

Details are claimed of a process and apparatus for contacting fluidized solid particles with gases and with combinations of solids and liquids.

U.S.P. 2,568,648. Method of Polymerizing Butadiene-1,3 Hydrocarbons in Aqueous Emulsion in the Presence of Mercapto-Substituted Monocarboxylic Acid Esters. J. C. McCool to The B. F. Goodrich Company.

A mixture of butadiene-1,3 and styrene is emulsion polymerized in the presence of 2-mercapto ethyl lambda-hydroxy stearate, which acts as a polymerization modifier.

U.S.P. 2,568,656. Copolymers of an Isoolefin and a Vinyl Cycloolefin. C. J. Parrish to The B. F. Goodrich Company.

A major proportion of an isoolefin with 4-5 C atoms, such as isobutylene, and a minor proportion of a vinyl cycloolefin, such as 1-vinyl-cyclohexene-3, are copolymerized at a temperature of —20° to —150° C. with a catalyst solution consisting of a Friedel-Crafts metal halide in a low freezing organic solvent, such as ethyl chloride.

U.S.P. 2,568,902. Beta Thioethyl Substituted Carbonyl Compounds as Modifiers in Ethylene Polymerization. R. B. Thompson and L. Schmerling to Universal Oil Products Company.

In the polymerization of ethylene in the presence of an organic peroxide catalyst and a certain type of diluent, an organic compound is added which contains a carbonyl group and has a thioethyl group on the C atom in beta-position to the carbonyl C atom. The S atom of the thioethyl group shall be attached directly to the beta C atom. The m.p. of the polymer is increased by the additive.

U.S.P. 2,569,383. Polymeric Hydrocarbon Drying Oils. G. F. Leyonmark and P. E. Hardy to Standard Oil Development Company.

A mixture of 70-50 percent by weight of propylene and 30-50 percent of a conjugated diolefin with 4-6 C atoms is copolymerized at a temperature of 50-

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AND GAIN INCREASED EFFICIENCY

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3 **Keep seating surfaces leak-free.** Only Sims guarantees the valve DISC will rotate every time it lifts. Does not hammer up and down on the same spot or require frequent replacement. You get three times longer wear from seat and disc—guaranteed.

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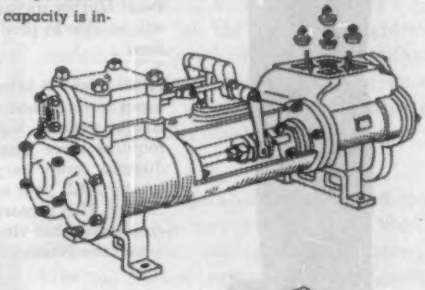

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110° C. under a pressure of 50-600 psi. in the presence of gaseous BF_3. A light-colored, hydrocarbon-soluble drying oil is obtained. Di- or tri-isobutylene may be added to the polymerization feed.

U.S.P. 2,569,391. Liquid-Liquid Contacting Tower. R. F. Stearns to Standard Oil Development Company.

Details are claimed of an apparatus for contacting two immiscible liquids of dissimilar specific gravity.

U.S.P. 2,569,447. Hydrogenated Rosin Acid Soaps in Butadiene-Hydrocarbon Aqueous Emulsion Polymerization. J. N. Borglin and P. A. Ray to Hercules Powder Company.

A mixture of a conjugated butadiene and a monoolefinic compound containing the $CH_2{=}C<$ group, such as styrene, is emulsion polymerized in the presence of an alkali metal salt of a purified hydrorosin acid as the emulsifier.

U.S.P. 2,569,448. Dehydroabietic Acid Salts as Emulsifiers in Aqueous Diolefin Polymerization. J. N. Borglin and P. A. Ray to Hercules Powder Company.

The process of this patent substantially differs from that of U.S.P. 2,569,447 only in that an alkali metal salt of dehydroabietic acid is here employed as the emulsifier.

U.S.P. 2,569,449. Aqueous Emulsion Polymerization of Styrene in the Presence of a Salt of Dehydroabietic Acid. J. N. Borglin and P. A. Ray to Hercules Powder Company.

The process according to U.S.P. 2,569,448 is used here for the emulsion polymerization of styrene alone.

U.S.P. 2,569,462. Emulsion Polymerization of Unsaturated Organic Compounds. A. E. Drake to Hercules Powder Company.

Compounds containing the $CH_2{=}C<$ group, such as styrene and/or butadiene-1,3, are emulsion polymerized in the presence of a catalyst comprising a water-soluble persulfate and an aryl (dialkyl) methyl hydroperoxide.

U.S.P. 2,569,463. Treatment of Naphtha Containing Oxygenated Compounds. D. B. Eastman to The Texas Company.

From the products of a Fischer-Tropsch synthesis a hydrocarbon fraction boiling between 100-400° F. and containing oxygenated compounds is separated. This fraction is passed in vapor phase together with 5-50 percent by weight (of the whole mixture) of steam into contact with fuller's earth at a temperature of 700-900° F. and a pressure within the range of from atmospheric to 25 psi. The octane value of the fraction is substantially improved by this treatment, a motor fuel being thus obtained.

U.S.P. 2,569,480. Emulsion Polymerization of Unsaturated Organic Compounds. E. J. Lorand to Hercules Powder Company.

The process of this patent differs from that of U.S.P. 2,569,462 substantially only in that an aryl (dialkyl) methyl hydroxide the alkyl groups of which do not contain more than four C atoms, each, is here employed as the catalyst.

U.S.P. 2,569,481. Homogeneous Polymerization of Unsaturated Organic Compounds. E. J. Lorand to Hercules Powder Company.

The process according to this patent

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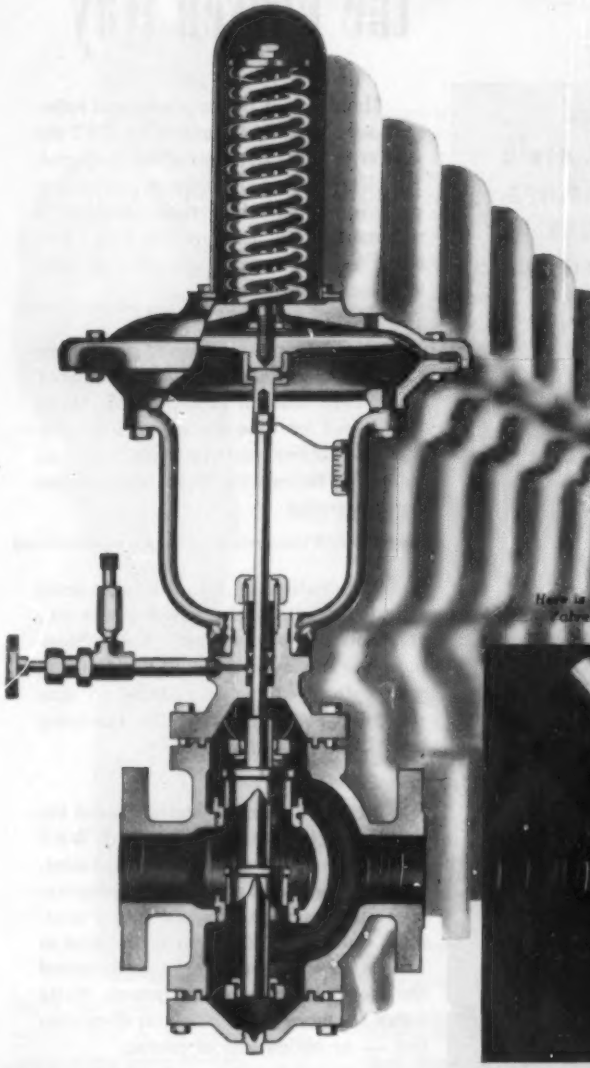

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STABILFLO CONTROL VALVES

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

is closely related to that of U.S.P. 2,569,480. The polymerization is effected in homogeneous phase.

U.S.P. 2,569,506. Emulsion Polymerization of Certain Vinyl Compounds Using a Mercaptan Modifier, a Hydroperoxide Catalyst, and Oxygen. E. J. Vandenberg to Hercules Powder Comany.

A styrene and/or a conjugated butadiene are emulsion polymerized in the presence of an alkyl mercaptan modifier, an organic hydroperoxide catalyst, and 0.01-0.4 percent of oxygen (based on the mononomer).

U.S.P. 2,569,688. Process for Making Conjugated Diene Copolymers. H. F. Park to Monsanto Chemical Company.

Details are claimed for the copolymerization of styrene with isoprene in the presence of a solution of the sodium salt of mahogany acids, a small amount of dodecyl mercaptan, and potassium persulfate.

U.S.P. 2,569,846. Method of Starting a Unit for High-Temperature Reactions. P. W. Cornell to Gulf Oil Corporation.

Details are claimed of a process for starting a unit employed in carrying out a high temperature exothermic reaction initiated at a temperature above 1000° F., particularly a reaction between natural gas and oxygen for the formation of synthesis gas.

U.S.P. 2,569,884. Emulsion Polymerization of Unsaturated Organic Compounds. A. E. Drake to Hercules Powder Company.

The process according to this patent is closely related to that of U.S.P. 2,569,448. The emulsion polymerization is effected here in the presence of an aqueous solution of an alkali metal salt of dehydrogenated resin and a water soluble persulfate contacted with a free-oxygen-containing gas for at least one-half hour.

U.S.P. 2,570,032. Method for Preparing an Olefin Polymerization Feed Stock. R. L. Heinrich to Standard Oil Development Company.

A naphtha containing olefins and oxygenated compounds is contacted with H_2S at a temperature of 40-260° F. The reaction product is freed from unreacted material, and the resulting fraction is used as a feed stock for catalytic polymerization.

U.S.P. 2,570,067. Hydrocarbon Conversion with Vanadia-and/or Molybdena-Containing Catalysts. J. W. Myers to Phillips Petroleum Company.

In the conversion of hydrocarbons in the presence of a vanadium or molybdenum oxide catalyst maintained at a temperature of 1050-1250° F., spent catalyst is regenerated in a reducing atmosphere at a temperature of 700-1025° F. with subsequent burning of the carbonaceous material by oxygen. The reactivated catalyst is reheated in a reducing atmosphere to the conversion temperature.

ISOMERIZATION

U.S.P. 2,568,964. Catalytic Isomerization of Olefinic Hydrocarbons. C. W. Montgomery, G. L. Sumner, Jr., and L. Berg to Gulf Research & Development Company.

Olefins are passed under isomeriza-

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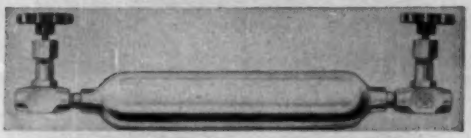

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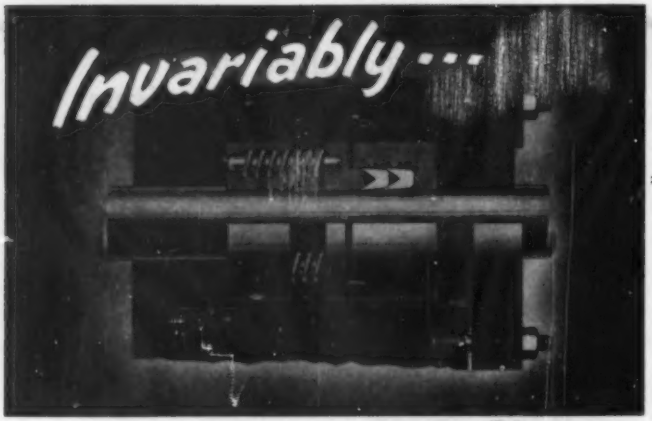

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Patents

tion conditions over a catalyst consisting of alumina impregnated with gaseous, anhydrous HF.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,567,932. Stagewise Process for the Hydrogenation of Carbon Monoxide. P. W. Garbo and E. W. Riblett to Hydrocarbon Research, Inc.

A gaseous CO/H_2 stream containing a solid particle form synthesis catalyst is passed through a first reaction zone for a residence time of not more than one second and under such conditions of elevated temperature that a major portion of the CO is consumed by incomplete reaction with H_2 to generate methylene groups adsorbed on the surface of the catalyst. The effluent from this zone including the catalyst and the adsorbed methylene groups is passed through a second zone at an elevated temperature considerably lower than that in the first zone and at a residence time considerably longer than that in the first zone. The conditions in this second zone are such that they are ineffective to synthesize organic compounds directly from H_2 and CO but are effective to polymerize the methylene groups into such compounds.

U.S.P. 2,568,841. Method of Synthesizing Gasoline Hydrocarbons. G. B. Arnold and H. V. Hess to The Texas Company.

In a Fischer-Tropsch synthesis, the

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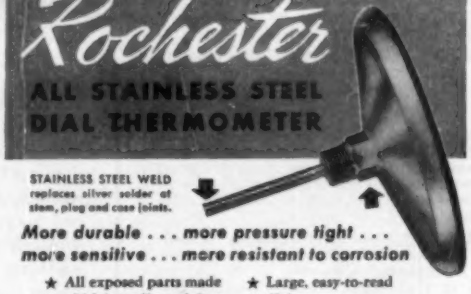

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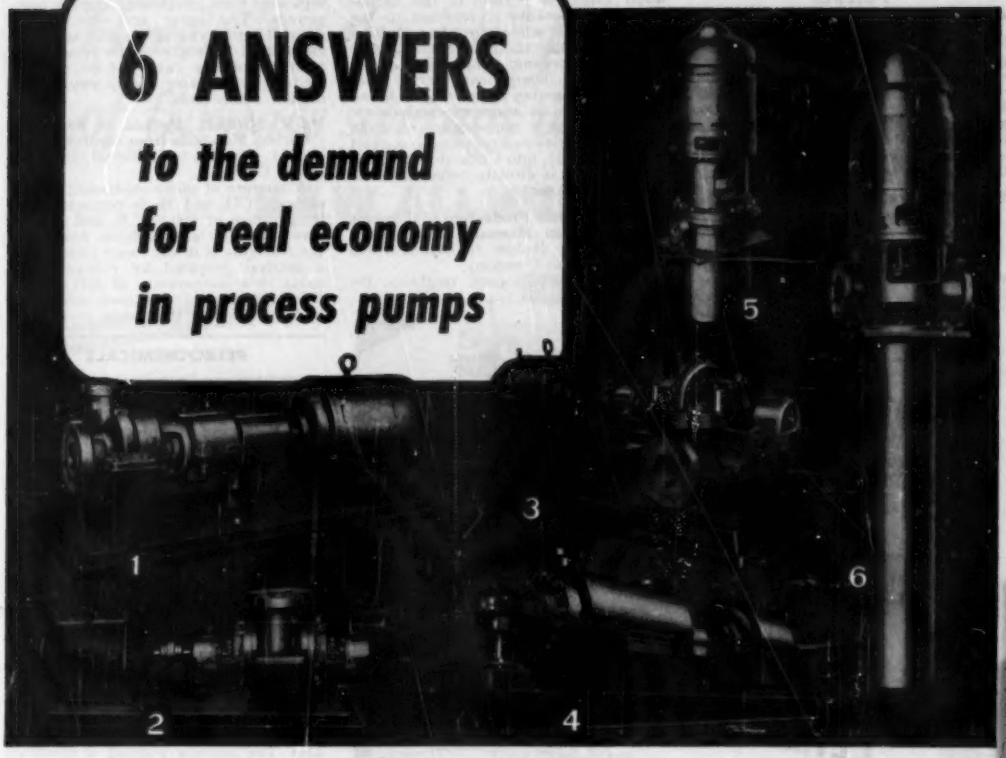

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		Two stage	200 to 1200 gpm	Heads to 1100 feet
3	Horizontally split with side suction and discharge	Single stage	30 to 2300 gpm	Heads to 750 feet
		Two stage	170 to 1300 gpm	Heads to 1100 feet
4	Diffusor type with "double-case" construction. Top suction and discharge.	Multi stage	450 to 3000 gpm	Heads to 6000 feet
5	Vertical pump, diffusor type	Multi stage	20 to 400 gpm	Heads to 4800 feet
6	Vertical pump, turbine type	One or more stages	60 to 35,000 gpm	Heads to 150 feet per stage

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Patents

reaction effluent is separated into a gas phase, a liquid hydrocarbon phase, and an aqueous phase. Oxygen-containing organic compounds distilling below 240° F. are separated from the hydrocarbon and the aqueous phase and recycled at least in part to the conversion zone to increase the yield of hydrocarbons in the gasoline range.

U.S.P. 2,568,953. Process for the Synthesis of Organic Compounds. N. L. Dickinson, E. F. Everett, and L. R. Hill to The M. W. Kellogg Company.

In a Fischer-Tropsch synthesis, the reaction effluent is first cooled to a temperature below 300° F. to condense water vapor. A portion of the uncondensed components is recycled to the reaction zone while another portion thereof is further cooled to below 100° F. to condense organic compounds formed. Uncondensed components from this second cooling step comprising CO_2 and H_2 are treated in a second catalytic reaction zone at a temperature of 1000-1500° F. and elevated pressure to convert the CO_2 and H_2 into CO and water. The resulting CO is directly recycled to the first reaction zone.

U.S.P. 2,569,380. Production of Alcohols from Carbon Monoxide and Hydrogen. C. H. Holder to Standard Oil Development Company.

In a Fischer-Tropsch synthesis, the normally liquid hydrocarbons formed are separated from oxygenated organic compounds. The latter are then hydrogenated with separated spent synthesis gas rich in hydrogen in the presence of a hydrogenating catalyst to produce alcohols from more highly oxygenated organic compounds.

U.S.P. 2,570,615. Method of Removing Carbon Monoxide from Hydrocarbons. C. H. Watkins to Universal Oil Products Company.

A mixture of olefin-containing hydrocarbons, CO, and H_2 is contacted at a temperature of 500-900° F. and a pressure such that a substantial portion of the reactants is in the vapor phase, with a catalyst prepared by reducing iron oxide at a temperature of 800-1200° F. CO is hydrogenated without substantial hydrogenation of the olefins present.

PETROCHEMICALS

U.S.P. 2,568,121. Preparation of Carbon Disulfide. H. O. Folkins, C. A. Porter, E. Miller and H. Hennig to The Pure Oil Company.

Details are claimed of a process for preparing CS_2 from a heated mixture of hydrocarbon gas rich in CH_4, such as natural gas, and sulfur vapor.

U.S.P. 2,568,660. Fluorination Process. R. Rosen to The U. S. Atomic Energy Commission.

A hydrocarbon is completely fluorinated by means of a fluid suspension of finely divided CoF_3 in a process claimed in detail.

U.S.P. 2,568,313. Manufacture of Resins from Aldehydes and Aromatic Hydrocarbons. T. G. Woolhouse and W. Lunn, England.

An aromatic hydrocarbon is reacted with an aldehyde in the presence of an acid. The reaction product is extracted with a water-immiscible organic solvent in the presence of an emulsion-breaking wetting agent. The resin produced is separated by neutralization.

U.S.P. 2,570,022. Production of Chlorinated Methyl Naphthalenes. H. S. Boyd-Barrett, J. R. Holker, and H. Steiner to Petrocarbon Ltd., England.

Details are claimed of a process for the production of side-chain chlorinated monomethyl naphthalenes by the vapor phase chlorination of methyl naphthalene.

U.S.P. 2,570,083. Production of Thiophene from Diolefin and Hydrogen Sulfide. E. F. Wadley to Standard Oil Development Company.

A mixture of butadiene, isoprene, or pentadiene with H_2S is heated in a silica lined reaction chamber without added catalyst to a temperature of 500-650° C. Thiophene is produced.

U.S.P. 2,570,215. Production of Formaldehyde from Oxidation of Butane. H. K. Dice to Celanese Corporation of America.

In the production of mixed oxygenated organic compounds by vapor phase partial oxidation of butane at elevated temperature, an aqueous formaldehyde solution is circulated through the hot reaction gases containing formaldehyde, acetaldehyde, methanol, acetone, and methyl ethyl ketone in order to halt the oxidation and to extract preferentially a portion of the formaldehyde formed. The unabsorbed formaldehyde in the reaction gases is extracted by water, and the

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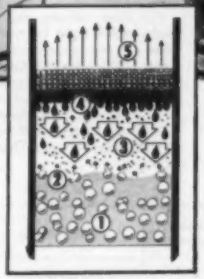

HOW IT WORKS

(1) Gas passes through liquid. (2) Bursting gas bubbles produce fine spray of liquid droplets. (3) Droplets are entrained in rising stream. (4) Droplets coalesce on knitted-wire surfaces to form large drops that fall back against the flow. (5) Gas passes on, freed from entrainment. The liquid is returned.

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dilute formaldehyde solution thus formed is added to the circulating solution.

U.S.P. 2,570,216. Treatment of Oxidation Products. H. K. Dice and R. L. Mitchell to Celanese Corporation of America.

The process of this patent is closely related to that of U.S.P. 2,570,215. Aliphatic hydrocarbons, generally, are here subjected to a corresponding partial oxidation, and the reaction gases are contacted with a cool formaldehyde solution. The acidity of the hot solution formed is maintained at a pH of no less than four by the addition of an inorganic neutralizing agent.

U.S.P. 2,570,722. Production of Thiophene Compounds from a Sulfur Dioxide and Hydrogen Sulfide Mixture. W. F. Sager to The Texas Company.

A mixture of H_2S and SO_2 and a hydrocarbon with an aliphatic chain of at least two C atoms is reacted in the presence of a particulate surface-active catalyst, e.g. a group VI metal oxide on a surface-active material, at a temperature of at least 700° F. and a space velocity less than ten weights of hydrocarbon per hour per weight of catalyst. Heterocyclic sulfur compounds containing a thiophene nucleus are produced.

DESULFURIZATION

U.S.P. 2,569,370. Method of Treating Petroleum Distillates. J. G. Browder and A. R. Smith to Standard Oil Development Company.

Mercaptan containing petroleum distillate with a final b.p. no greater than 750° F. is mixed with not more than one percent by volume of a naphthenic acid. A solution of an alkali metal hydroxide is then added in an amount no greater than five percent by volume together with a mild oxidizing agent to convert the mercaptans to disulfides and to sweeten the distillate.

U.S.P. 2,570,277. Sweetening Process. H. A. Ricards, Jr., and J. W. Ryder to Standard Oil Development Company.

A hydrocarbon mixture is freed from mercaptans by first contacting it with a caustic solution and then contacting it, after removal of this solution, with another caustic solution which has at least 1-3 percent lower concentration than that employed before. Agents which increase the solubility of mercaptans and mercaptides in this solution, such as aliphatic acids with 3-7 C atoms, are used therewith.

U.S.P. 2,570,278. Sweeting Process Using Alkali Metal Hydroxide Containing High-Boiling Mercaptan Salts. J. W. Ryder to Standard Oil Development Company.

Hydrocarbon fractions boiling in the 400-700° F. range are freed from mercaptans by contact with a caustic solution. The partially spent caustic solution containing mercaptans is segregated and contacted with a hydrocarbon fraction boiling in the 80-420° F. range, whereby the mercaptan content of the motor fuel fraction is substantially reduced.

HEAVY OILS AND WAXES

U.S.P. 2,568,472. Oil Compositions Containing Amine Salts of Acid Compounds of Boric Acid and Hydroxy Carboxylic Acids. C. E. Trautman to Gulf Research and Development Company.

A hydrocarbon oil is compounded with a minor amount (e.g. 0.001-0.5 percent by weight) of an amine salt of an acid compound of boric acid and a hydroxy carboxylic acid in which the OH group and the COOH group are separated by no more than two C atoms. The new oil composition has improved stability characteristics.

U.S.P. 2,568,583. Method of Separating Impurities from Used Lubricating

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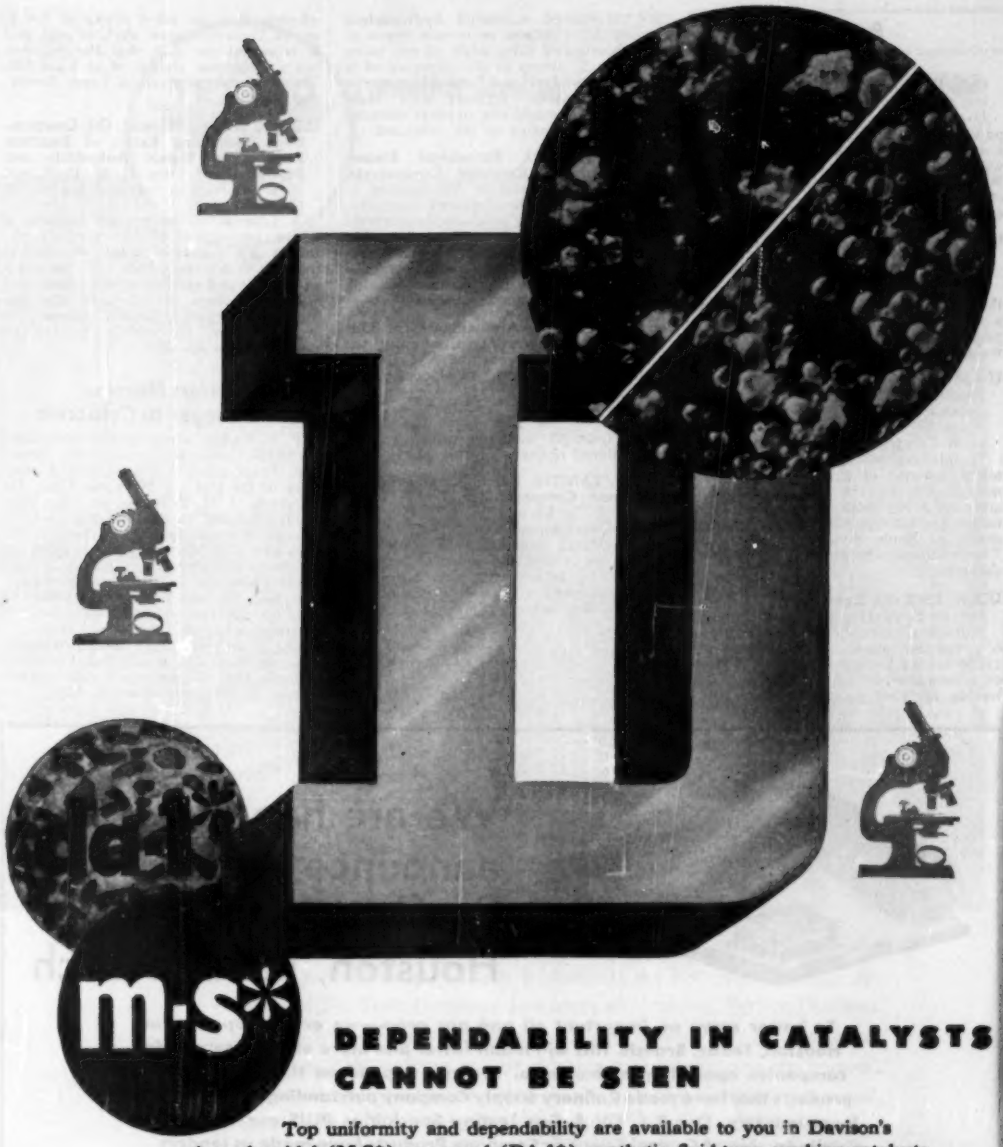

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Patents

Oils. E. F. Graves to The Dow Chemical Company.

Used lubricating oil is freed from dispersed impurities by dissolving in the oil a minor proportion (e.g. 0.2-1 percent by weight) of N-phenyl ethanolamine, N-phenyl diethanolamine, or N-phenyl ethanolisopropanolamine. The additive causes aggregation of the impurities.

U.S.P. 2,568,946. Manufacture of Paraffin Waxes. H. S. Burk to Gulf Research & Development Company.

Details are claimed of a process for the manufacture of paraffin wax from a slack wax consisting of crystalline paraffin waxes and 25-60 percent by weight of oil.

U.S.P. 2,568,965. Coal Acid Esters as Synthetic Lubricants. C. W. Montgomery, W. I. Gilbert, and R. E. Kline to Gulf Research & Development Company.

A mineral lubricant oil contains a minor amount of a neutral ester of a monohydric alcohol and a mixture of aromatic acids obtained by the oxidation under special conditions of an alkaline slurry of finely divided coal or coke. The additive retards rusting of metal surfaces.

U.S.P. 2,569,122. Lubricant. D. E. Adelson to Shell Development Company.

A mineral oil contains a minor amount of a reaction product of an unsaturated cyclic ketone having at least 12 C atoms or a monoolefinic aliphatic hydrocarbon having at least eight C atoms with a polychlorinated saturated hydrocarbon having 1-2 C atoms or certain types of polychlorinated fatty acids of not more than six C atoms in the presence of a peroxide catalyst, and further treatment of this reaction product with H_2S-$NH_4H.S$. The additive imparts extreme pressure properties to the lubricant.

U.S.P. 2,570,023. Parasicidal Steam-Cracked Oil Emulsion Concentrate. C. S. Carlson and M. W. Swaney to Standard Oil Development Company.

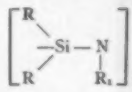
A parasicidal oil emulsion concentrate comprises an emulsifier and a highly aromatic, synthetic, steam-cracked petroleum paraffin gas oil fraction cracked under specific conditions and having specific physical characteristics.

U.S.P. 2,570,402. Antioxidants for Oils and Oil Compositions Containing the Same. D. R. Stevens and A. C. Dubbs to Gulf Research & Development Company.

A lubricating oil contains a small amount of bis (2-hydroxy-3-t-butyl-5-methylphenyl) methane, which retards oxidational changes of the oil.

U.S.P. 2,570,719. Foam Suppressed Lubricant Compositions. H. W. Rudel and A. D. Kirschenbaum to Standard Oil Development Company.

A mineral lubricating oil contains a detergent or similar foam promoter and 0.0001-0.01 percent by weight (of the total composition) of a polyamino-silicane of the formula



wherein R is an alkyl group of 1-4 C atoms, R_1 is hydrogen, akyl, or aryl, and X is an integer such that the polymer has a molecular weight of at least 300. This additive suppresses foam formation.

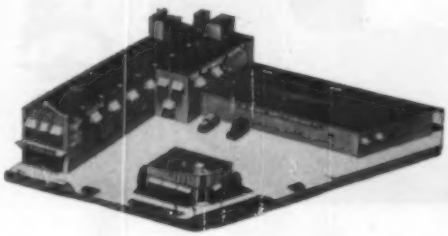
U.S.P. 2,570,846. Mineral Oil Compositions Containing Esters of Reaction Product of Maleic Anhydride and Styrene. F. P. Otto, O. M. Reiff, and R. W. Barrett to Socony-Vacuum Oil Company, Inc.

A mineral lubricating oil contains a minor proportion of the product obtained by copolymerizing six weight parts of maleic anhydride and five parts of styrene and esterifying the copolymer with a mixture of saturated aliphatic alcohols containing 12-14 C atoms in a straight chain. The additive lowers the pour point of the oil.

Shell Transfers Houston Plant Manager to California

F. E. Caddy, formerly superintendent of Shell Chemical Corporation's Houston, Texas, plant, has been named manager of the plant in Martinez, Calif. He succeeds O. M. Williams, who has been made assistant to the vice president in charge of manufacturing in New York.

A native of Wyoming and a graduate of Stanford University, Caddy joined Shell Chemical in 1931 as a laboratory assistant. He later held various technical and administrative posts in chemical manufacturing at Dominguez and Torrance, Calif., becoming senior technologist in Shell Chemical's San Francisco office in 1947. He was made superintendent of the Houston plant in 1948.



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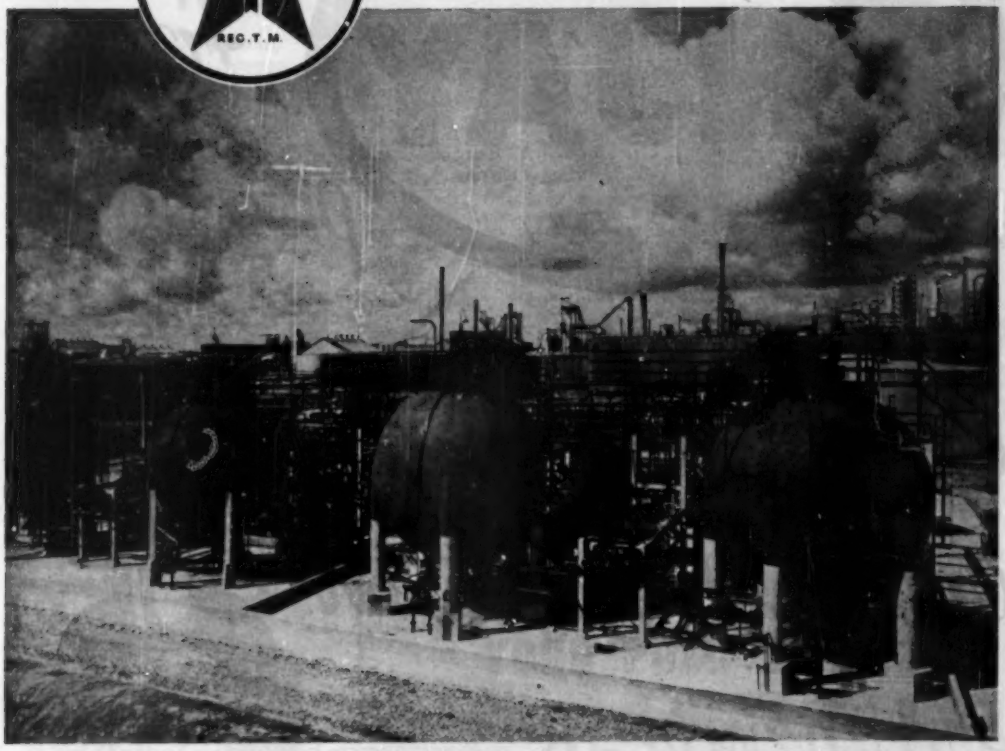

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About EQUIPMENT and SERVICE Suppliers

Master Tank & Welding, Dallas, Names Tom Haley Sales Manager

Tom Haley, who has been associated with the Master Tank and Welding Company of Dallas since its organization, has been promoted to sales manager.

Haley

Prior to joining Master Tank and Welding he was sales manager of Master Petroleum Company.

Haley attended North Texas Agricultural College and Irving, Texas, high school.

C. A. McGee has been promoted to the position of office manager. Both promotions were announced by Sam Weempe, partner of Master Tank and Welding.

John Gossett Elected Chairman Of Directors for Two Companies

At the recent meeting of the directors of Cenco Corporation, the parent stockholding company, and Central Scientific Company, John T. Gossett, president of Central Scientific Company, was elected chairman of the board of directors of both companies, succeeding the late chairman, E. Perry Holder.

Three Added to B-I-F Industries Staff in Managerial Capacities

New personnel has been appointed by B-I-F Industries to its offices in Pittsburgh, Minneapolis and Providence, R. I. Douglass Taber, a Brown University graduate, has joined the company as manager of the Pittsburgh office. Since 1936, Taber has been associated with Greeley and Hansen, consulting engineers in Chicago.

Alden Carpenter, a graduate of the University of Minnesota, and formerly associated with Hitchcock and Estabrook, consulting engineers in Minneapolis, will take charge of the Minneapolis office.

Raymond McIndoe, formerly with the Pennsylvania department of health and a graduate of Rice Institute, Houston, has been appointed assistant manager of the Standard and Engineered Products Division of Builders-Providence, Inc.

Bob Farmer Promoted to Sales Engineer by General Controls

Robert L. (Bob) Farmer, an employe of General Controls Co., manufacturers of automatic pressure temperature, level and flow controls since 1943, was recently appointed factory sales engineer.

Farmer

Farmer, who majored in engineering at Stanford University, will concentrate on sales engineering in the aircraft field, where most of his work will deal with the Company's hi-g line of electrically operated valves, pressure and temperature controls.

Farmer, previously attached to the Dallas factory branch office, was transferred to Glendale in 1951.

Multiple Du Pont Transfers Are Effective January 1, 1952

Du Pont has announced it will transfer four district office managers with changes effective January 1.

R. M. Glover, presently engaged at the Washington sales office, will become manager at Tulsa. He joined the company in 1947 as a salesman in the Wilmington office and served in both the Mid-Continent and Gulf Coast area before being transferred to Washington last February. He is a Rice Institute graduate and was associated with Humble Oil & Refining Company before

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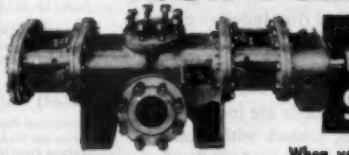

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TOTAL..... $3350.00	TOTAL..... $3430.00	

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Ammonium Fluoborate
Potassium Fluoborate
Sodium Fluoborate

ALKALI FLUORIDES
Ammonium Fluoride
Potassium Fluoride
Sodium Fluoride

DOUBLE FLUORIDES
Potassium Aluminum Fluoride
Potassium Chromium Fluoride
Potassium Ferric Fluoride
Potassium Titanium Fluoride
Potassium Zirconium Fluoride

METAL FLUORIDES
Aluminum Fluoride, Crystal
Antimony Trifluoride
Antimony Pentafluoride
Barium Fluoride
Cadmium Fluoride
Calcium Fluoride
Chromium Fluoride
Cobalt Trifluoride
Copper Fluoride
Ferric Fluoride
Lead Fluoride
Magnesium Fluoride
Molybdenum Hexafluoride
Nickel Fluoride
Strontium Fluoride
Titanium Tetrafluoride
Tungsten Hexafluoride
Zinc Fluoride
Zirconium Tetrafluoride

METAL FLUOBORATE SOLUTIONS
Cadmium Fluoborate
Chromium Fluoborate
Cobalt Fluoborate
Copper Fluoborate
Ferrous Fluoborate
Indium Fluoborate
Lead Fluoborate
Nickel Fluoborate
Silver Fluoborate
Stannous (Tin) Fluoborate

NON-METAL FLUORIDES
Boron Fluoride Gas
Boron Fluoride—Diethyl Ether Complex
Boron Fluoride—Phenol Complex
Boron Fluoride—Other Complexes
Sulfur Hexafluoride

HALOGEN FLUORIDES
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Genetron 150—$CH_2 = CF_2$
Genetron 160—$CHCl = CF_2$
Genetron 170—$CCl_2 = CF_2$
Genetron 265—$CClF = CF_2$

*The products listed include those which are commercially available as well as a few presently produced only in experimental quantities. For further information on any of these, or on other fluorine compounds you may require, consult the General Chemical Product Development Department.

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serving with the Navy during World War II.

Charles D. Towery, present manager at Tulsa, will be transferred to Houston to manage the Gulf Coast district. A graduate of Texas A. & M. College, he was formerly with Bethlehem Supply Company of Houston.

Alfred R. Mullins, district manager at Houston, has been named manager of the eastern district with offices in New York City. Mullins joined Du Pont in 1947 as a service representative.

E. Hern Simpson, acting manager of the eastern district office, will return to Wilmington to resume his duties as sales manager of the petroleum chemicals division.

American Meter Appoints Kiraly Assistant to Production Head

American Meter Company, manufacturers of displacement gas meters, etc., has appointed Joseph L. Kiraly as assistant to the vice president of production. Kiraly attended Fenn College and received the degree of Industrial Engineer. Prior to service with American, Kiraly was with Stevenson, Jorday and Harrison, management consultants of New York, for nine years. He assisted in surveying and installing modern managerial methods covering job evaluation, incentive plans, production routines and payroll routine plans.

Kiraly

Assistant Regional Managers Named from Cummins Engine Staff

Cummins Engine Company, Inc., has promoted two sales engineers who had been working at their Columbus, Ind., factory to assistant regional manager capacity.

R. A. D'Amour has been transferred to Washington, D. C., to assist John W. Post. He joined Cummins in August, 1948, as a trainee engineer and was named sales engineer in May, 1949. A mechanical engineering graduate of Michigan College of Mining and Technology at Houghton, he served with the Navy for four years.

G. W. Plondke, a veteran Navy pilot, has been appointed assistant to Fred W. Hartmann, regional manager of the central area with offices in Chicago. Plondke graduated from George Washington University in Washington, D. C. with a B.S. in mechanical engineering. He affiliated with Cummins in 1948 and was subsequently named sales engineer in February, 1949.

General Electric Promotes Two Within Apparatus Sales Division

General Electric Company revealed two key appointments made recently in their Apparatus Sales Division.

Gerald L. Phillippe, Schenectady, N. Y., was named manager of the division's financial department. A graduate of the University of Nebraska in business administration, he joined G-E in 1933 as a student in the accounting disbursements division. Subsequently he was named

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100% Serrated Safety Grating by A. O. Smith

A. O. Smith 100% serrated safety floor costs no more than a plain surface floor. You get premium quality with *positive* safety protection—*at no premium in price!*

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THEN SELECT
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SUPERIOR FEATURES!

1. STRONG electro-forged construction for easy installation.

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3. EASY TO MAINTAIN...paint reaches entire surface.

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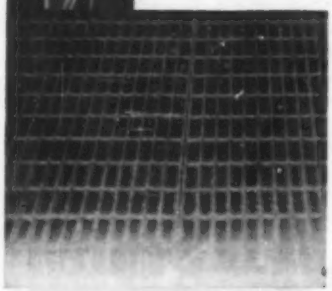
5. SAFE footing at all times with twisted cross bar.

Write for complete specifications



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Pittsburgh 22, Pa.

BLAW-KNOX
Electroforged STEEL
GRATING AND STAIR TREADS

traveling auditor, statistician. Apparatus department auditor and comptroller.

Woods McCahill, a Massachusetts native who graduated from Harvard University and from Harvard Law School, has been appointed counsel of the G-E law department, with headquarters in Schenectady. He joined G-E in 1946 as an attorney in the Apparatus division and held that position until his present promotion.

Carborundum Company Appoints Southwest Sales Representative

Roy W. Brown has been appointed direct sales representative in the Southwest for The Carborundum Company of Perth Amboy, N. J. Formerly a product specialist for Carborundum's "Monofrax" fused cast refractory line, Brown will handle all refractory products of The Carborundum Company in his new assignment.

Brown

A ceramic engineering graduate of Rutgers University, and later research associate and instructor there, Brown has been with The Carborundum Company since 1947.

Six Sales Staff Promotions Are Announced by Columbia-Southern

Several promotions within the Columbia-Southern Chemical Corporation sales organization were announced recently. C. F. Bingham, manager of pigment sales, and J. F. Dockum, Philadelphia district sales manager, have been appointed assistant directors of sales.

P. A. Fodor, formerly in the Market Research and Development department at Pittsburgh, succeeds Dockum at Philadelphia as district sales manager. R. M. Simpson becomes manager of pigment sales.

E. M. Rollins has been named district sales manager at Dallas, with sales supervision of the Houston and New Orleans branch offices. C. J. Stroemple has been transferred from Barberton, Ohio, to the Market Research and Development department at Pittsburgh.

Thomas Griffin Transferred To Worthington Holyoke Works

Worthington Pump and Machinery Corporation recently appointed Thomas F. Griffin as Holyoke Works Purchasing Agent, succeeding Milton Roberts who resigned. Griffin, a resident of Springfield, N. J., will make his new headquarters at Holyoke, Mass. An employe of Worthington for ten years, he has served as purchasing agent, assistant in the general purchasing department, and since May, 1950, general buyer.

LeRoy D. White, coordinator of the Contract Engineering Division previously named general buyer, is a resident of East Orange, N. J., and has been a company employe for eight years.

Welch, National Lead Veteran, Named Head of Metal Department

William J. Welch, a member of the National Lead Company since 1916, has been appointed manager of the company's metal department. He assumed

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are crystal clear with
MACBETH GAUGE GLASSES
BRAND

In steam service, you can depend on Macbeth brand gauge glasses to stay crystal-clear permanently. They resist fogging, pitting, etching and staining . . . provide maximum visibility at all times, even at a distance.

OUTLAST ALL OTHER TYPES—Shock tests show that Macbeth gauge glasses can be heated to 425°F. and then plunged into ice water . . . *without breaking!* And the extremely low coefficient of expansion of Macbeth brand glasses permits heavier construction for additional mechanical strength . . . assures longer life than any other type of gauge glass. Precision made for accurate fit and easy installation, Macbeth Gauge Glasses provide inexpensive protection for your boiler investment. Available in plain, reflex, and high pressure types through your Mill Supply Distributor.

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Gauge Glasses, Sight Glasses, Oil Cup and Lubricator Cup Glassware.

• 100 Years of Making Glass Better and More Useful •

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SPECIFY →

Tenamene

the most effective gasoline additives known!

FOR 15 YEARS Tennessee Eastman has manufactured the most effective and efficient gum-inhibiting gasoline additives known to the refining industry.

While the name, TENAMENE, is new to the industry, the products themselves are not. Formerly these inhibitors were sold through another company and under that company's name. Today these additives are available directly from the basic manufacturer.

Whether you have been using these Eastman additives under another name or not, you'll find TENAMENE represents the peak in quality and performance. And more than this, you'll enjoy doing business with Tennessee Eastman.

We will be pleased to send you specifications, prices and samples. Write to Tennessee Eastman Company, Kingsport, Tennessee, or call our nearest sales representative.

WHICH DO YOU NEED?

Tenamene 1

a gum inhibitor for motor fuels →

Specific Gravity, 75 /75 F.	0.89-0.91
Viscosity at 100 F. (Saybolt Universal)	49 secs.
Freezing Point	—27 F.
Flash Point (Tag Closed Cup)	61 F.

Tenamene 2

← *a gum inhibitor for motor fuels and aviation gasolines*

Specific Gravity, 75 /75 F.	0.94-0.95
Viscosity at 100 F. (Saybolt Universal)	63 secs.
Melting Point	>64 F.
Flash Point (Cleveland Open Cup)	285 F.

Tenamene 60

a copper deactivator →

Specific Gravity, 75 /75 F.	1.07
Viscosity at 100 F. (Saybolt Universal)	80 secs.
Freezing Point	—1 F.
Flash Point (Tag Closed Cup)	19 F.

Tenamene EASTMAN GASOLINE ADDITIVES

STOCKS OF TENAMENE are carried in Lodi, New Jersey; Houston; Los Angeles; San Francisco; and Kingsport, Tennessee.

SALES REPRESENTATIVES: New York—10 E. 40 St.; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; Houston—412 Main St. **West Coast: Wilson Meyer Co.,** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth Ave.; Seattle—821 Second Ave.

TENNESSEE EASTMAN COMPANY, *Division of Eastman Kodak Company,* KINGSPORT, TENNESSEE

managership of the metal sales department in October, 1947, but prior to that time worked with the U. S. Cartridge Company, the Atlantic Branch metal sales department, and Morris P. Kirk & Sons, Inc., all subsidiaries of the National Lead Company.

Metallizing Engineering Names Julius Nill Southern Manager

Julius H. Nill has been appointed southern regional manager for Metallizing Engineering Company, Inc. whose offices are in New Orleans. An employe since 1945, he had been the field engineer handling sales in the middle and southern Atlantic states. As such he devoted much thought to the problems of salt and industrial atmospheric corrosion. Nill's 25 years experience in the mechanical engineering field includes marine and industrial engineering, and war-time experience as an outfitting superintendent in Gulf and Atlantic coast shipyards.

Nill

Marley Opens Washington Office; Cousins Is Manager

This month the Marley Company, Inc., manufacturers of Marley water cooling towers and air-cooled heat exchangers, opened a Washington, D. C., engineering service office located in the Wyatt Building. Don Cousins, a graduate of the University of Kansas School of Engineering, and formerly associated with the company in Kansas City, has been named manager. The Washington office will render comprehensive service to governmental agencies and private industry within that area.

ATTENDING THE AIRETOOL Manufacturing Company sales conference at Springfield, Ohio, were principal officers of the firm: W. T. Hamilton, president; O. F. Hamilton, secretary; R. B. Gordon, vice president; R. E. Baker, vice president, engineering; I. T. Thornson, sales manager; and L. B. Miller and H. C. Mathews, sales engineers. The 42 representatives in attendance came from 17 states, Mexico and Canada. The company produces tube cleaners, tube expanders and

Sweeney Heads Houston Branch For Refinery Supply Company

V. F. Sweeney, Jr., has been appointed to manage the newly opened Houston office for The Refinery Supply Company of Tulsa. The company manufactures R. S. oil and gas testing specialties, and is exclusive distributors for the Central Scientific Company. The new branch office is located at 2215 McKinney Ave.

English Joins Pipe Protection As Vice President for Sales

E. Rowland English has joined Pipe Protection Service, Inc., of Elizabeth, N. J., as vice president in charge of sales. He will also serve as assistant general manager. English was formerly Eastern division manager for H. C. Price Company. Pipe Protection Service operates coating and wrapping plants at Elizabethport, N. J., Lowell, Mass., and at customers' job sites.

Arthur Bartling Named Manager G-E's Apparatus Sales Division

Arthur W. Bartling of Lynn, Mass., has been named manager of product

Tempilstiks°

The amazing CRAYONS that tell temperatures

For heat-dependent operations, control temperatures with TEMPILSTIKS°. Simplicity, accuracy, and economy have made them standard equipment in thousands of industrial plants. Available for 56 different temperatures from 113° to 2000°F—one for every temperature commonly specified for ***welding, flame cutting, tempering, forging, casting, molding, drawing, straightening,*** and scores of other heating operations. Eliminate guesswork. Order today.

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ALSO AVAILABLE IN LIQUID OR PELLETS

it's this **SIMPLE**

1. Select Tempilstik° for working temperature you want.
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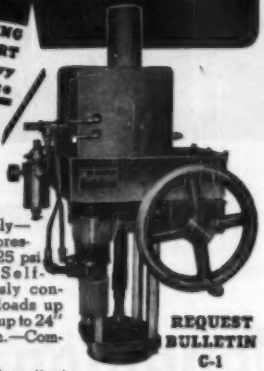
NEW! GEAR-DRIVEN PNEUMATIC OPERATOR FOR THROTTLING CONTROL SERVICE

Rotomotor

PNEUMATIC POWER POSITIONING OPERATOR

ACCURATE POSITIONING TO WITHIN 1/500th PART of STEM TRAVEL on Heavy Duty Throttling Service



A wholly new and different valve operator employing a reversible pneumatic motor and a precision gear driven screw stem, with these AMAZING advantages:

Operates on 100 psi supply—Sensitivity to instrument pressure changes as small as .025 psi—Perfect stability—Self-locking stem—Continuously connected handwheel—Stem loads up to 40,000 lbs.—Stem travels up to 24" Stem speeds up to 36" p.m.—Compact design.

So different, you will want to investigate its possibilities immediately.

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Conoflow Controls

CONOFLOW CORPORATION

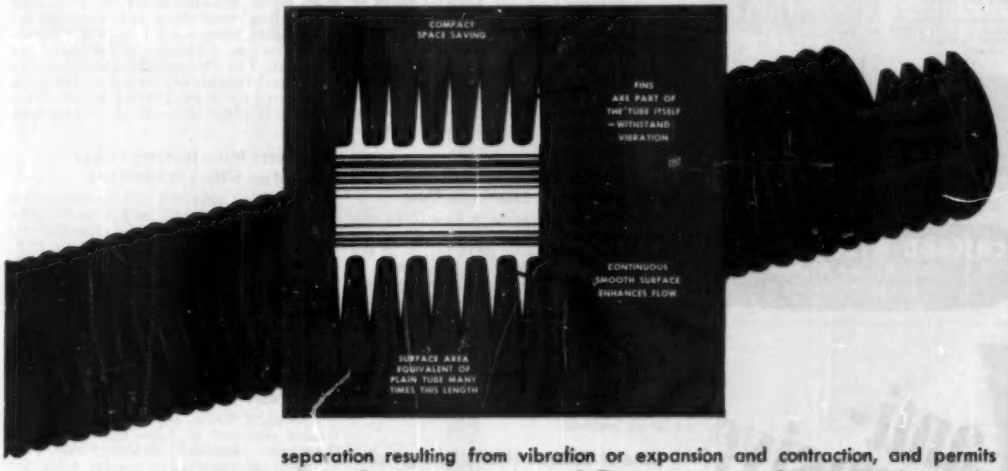
2100 Arch St., Phila. 3, Pa.

HIGHER EFFICIENCY

These six words briefly describe the noteworthy performances that Wolverine Trufin*—the integral finned tube—is showing wherever it forms a part of heat exchangers.

As if developed expressly for the defense effort, Trufin is THE answer to today's cry for more production because it possesses the physical advantages of greater capacity.

Just a glance at its unique construction will tell you why Trufin performs so well. Note that the fins are part of the tube itself. Thus there is a positive, uninterrupted thermal flow. This one-piece construction removes the hazard of fin and tube



separation resulting from vibration or expansion and contraction, and permits more uniform temperature control. The space-saving advantage is obvious; the equivalent outside surface area of a 19" length of plain tube, ⅝" diameter, for instance, can be obtained in just one inch length of Trufin of the same diameter. The continuous, smooth surface between the fins, too, enhances the flow of liquids through them and lessens the tendency for the formation or accumulation of obstructions that necessitate more frequent cleaning.

Trufin is available in a variety of alloys, including bi-metal; in a wide range of sizes, fin spacings and heights. If you are retubing or installing new heat exchangers or condensers, consider Trufin—the tube recognized for its high efficiency.

Would you like a Bulletin that gives detailed information about operating heat exchangers efficiently? Ask for a copy on your stationery. *Reg. U. S. Pat. Off.

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ontario.

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Manufacturers of seamless, nonferrous tubing
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Wolverine Condenser tubes stocked by Butler Industries, Inc., 355 South Fourth Street, Beaumont, Texas. Telephone Beaumont 5-2351.

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GASKETS
Proved in Service in the
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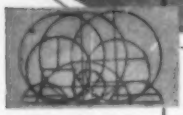

GASKETS FOR HEAT EXCHANGERS, COOLERS AND CONDENSERS

Gaskets cut from solid metal, sheet-packing, or double jacket type as needed.

Corrugated metal gaskets for refinery use. Made of ingot iron, Terne-plate, aluminum, stainless steel and monel in sizes from 1 inch up.

A.P.I. ring gaskets for high pressure lines for use on ring-type flanged joints. Made of soft iron and all standard steel alloys in oval and octagonal shapes.

See page 232 in the Refinery Catalog.

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anti-corrosive
strapping and seals

Our specialized service will supply just what you need for securing insulation to forms, pipe lines and tanks.
Strapping and Seals produced in
MONEL ALUMINUM
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Strapping Tools for applying.

FREE
Handy calculator—one side tells you which strap to use for any given corrosive condition; other side determines length and weight of strap required for any binding operation.

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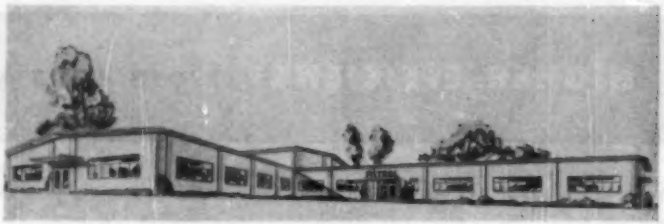

TILT-UP TYPE WALLS of the Filtrol Corporation research building being erected at Vernon, Calif., will be constructed of reinforced concrete slab with poured columns and roof beams. Individual laboratories and offices will be separated by fire-proof walls of metal stud and plaster construction. Completion of the new building is expected before the middle of 1952. Filtrol Corporation is currently supplying 50 percent of all cracking catalysts sold to the petroleum industry. The company completed a $3 million catalyst plant in Salt Lake City earlier this year.

sales practices for the General Electric Company's Apparatus Sales Division and will make his headquarters in Schenectady. Bartling was general sales manager of the Small Apparatus Division before his appointment. He is a graduate of the University of Illinois where he received a B.S. in electrical engineeering and has been a employe of G-E since 1919.

Carrier Installs Centrifugal Refrigeration at Monsanto Plant

Carrier Corporation is installing the first large centrifugal ammonia compressor ever installed in the U. S. at the Monsanto Chemical Company plant in Nitro, W. Va. It will be used for process refrigeration. The five-stage centrifugal compressor, driven by a 600 hp. motor, will double the capacity of the existing reciprocating ammonia system. The new unit will serve as the low stage compressor in the Monsanto plant, taking the ammonia at 25 pounds suction pressure and discharging it to the high stage at 75 pounds.

General Controls Names Wengerter Division Manager in New York

Felix Wengerter has been appointed district manager of the New York branch office for General Controls Company of Glendale, Calif. He was given complete charge of all New York and Newark branch office territory activities for General Control's line of automatic controls.

Wheelco's Western Sales Unit Moved to Larger Chicago Office

Offices of the Western Division sales organization of Wheelco Instruments Company, manufacturers of industrial measuring, controlling and recording instruments, were moved to 2320 Milwaukee Avenue, Chicago, to facilitate expansion. The Chicago office which serves as sales headquarters for agents covering the territory from Detroit to the West Coast, is directed by R. A. Schoenfeld.

EXCEL-SO
COALESCERS
remove all free water from products streams prior to dessicant dehydration.
Send For Descriptive Bulletin
WARNER LEWIS COMPANY
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Air Filter Manufacturer Opens Canadian Office in Montreal

Canadian activities of American Air Filter Company, Inc., at Louisville, after January 1, 1952, will be handled by American Air Filter of Canada, Ltd., Montreal, under the direction of William G. Hole, formerly of Darling Bros., Ltd. Representative in larger Canadian cities will handle the AAF line of air filters, electronic precipitators and Roto-Clone dust collectors.

Lion Oil Names Kelly Manager Of Western Division Sales

Douglas Kelly, Jr., formerly assistant sales manager of Lion Oil Company's western chemical division, has been named manager of chemical sales for that division and will continue his headquarters in El Dorado, Ark. Kelly joined Lion Oil in August, 1949, as a field representative in chemical sales, but previously had been associated with The Barrett Division, of Allied Chemical & Dye Corporation. He is a graduate of Tulane University, New Orleans.

Timken Roller Bearing Company Appoints Lyle to Buffalo Office

The Timken Roller Bearing Company has appointed Sherman R. Lyle of its Cleveland office to the position of district manager of the Steel and Tube division, Northern Pennsylvania and New York State district.

Lyle, who joined The Timken Roller Bearing Company in 1940, is a graduate of Case Institute of Technology. He has been with the Timken Company as sales engineer for the Cleveland district since 1946. Lyle's new office will be located in Buffalo.

Warner Lewis Company Expands Plant Fabrication Facilities

Construction has already started on a plant expansion program involving new fabrication equipment and a new building for Warner Lewis Company. The new facilities, across the street from their present location at 817 N.

cutting oils work better

The addition of Monsanto's Santolube 52, a new oil additive, to your cutting oil formulations steps up tapping efficiency . . . steps up threading efficiency . . . lengthens tool life.

As little as 2% of Santolube 52 may replace as much as 10% fatty oil component of certain cutting oil types and yet give improved tapping and threading efficiency.

Santolube 52 contains no sulfur or chlorine, therefore makes no difference in the ratio of these elements in your cutting fluids.

Investigate Santolube 52 as an economical additive . . . as a means of helping your customers obtain longer tool life. For information, write MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1775-L South Second Street, St. Louis 4, Missouri.

Typical Inspection Values for SANTOLUBE 52

Specific Gravity at 60°/60° F.	0.97
Viscosity, S.U.S. at 210° F.	99
S.U.S. at 100° F.	2300
Color, ASTM	3.5
Neutralization Number	5—12
% Phosphorus	Nil

Santolube: Reg. U. S. Pat. Off.

SANTOLUBE 52

MONSANTO
CHEMICALS — PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

IS VACUUM THAT'S 99.99% PERFECT

good enough for your process?

THIS degree of vacuum is easily obtained with the Croll-Reynolds four or five-stage steam jet EVACTOR, with no moving parts. Each stage from a technical standpoint is as simple as the valve that turns it on. Numerous four-stage units are maintaining industrial vacuum down to 0.2 mm. and less, and many thousands of one, two and three-stage units are maintaining vacuum for intermediate industrial requirements on practically all types of processing equipment.

By permitting water, aqueous solutions or any volatile liquid to evaporate under high vacuum and without heat from an outside source, enough BTU's can be removed to chill the liquid down to 32° F., or even lower in the case of solutions. This is the principle of the Croll-Reynolds "Chill-Vactor." Hundreds of these have been installed throughout the United States and in several foreign countries.

An engineering staff of many years experience has specialized on this type of equipment and is at your service. Why not write today, outlining *your* vacuum problem?

C-R REYNOLDS

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17 JOHN STREET, NEW YORK 38, N. Y.

Chill-Vactors Steam Jet Evactors Condensing Equipment

BEAVER 26-R

the only tool of its kind that . .

. . . cuts either standard "taper" or electric "straight" conduit threads by a simple adjustment.

. . . has "radio" dial size-setting. Dies can be removed in a few seconds FROM THE OUTSIDE without use of tools.

. . . is fully-adjustable and easy-working. The only 1 to 2-inch pipe threader that cuts standard, oversize and undersize threads of uniform standard length.

The Beaver 26-R uses one set of dies to thread four sizes—1, 1¼, 1½ and 2-inch. It is fully-adjustable for oversize or undersize threads to compensate for variation in fittings. There's a cam-type universal self-centering chuck, too, which centers the pipe accurately and insures straight pipe lines. Yet, "drip threads" may be cut when desired for heating lines.

Your customers benefit from the advantages of Beaver 26-R. Why not tell them about it today?

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On the job throughout the industry!

You find SUPERIOR equipment wherever efficient, modern operation is needed. Why? Because the industry knows that we manufacture refinery and gasoline plant equipment that operates under the toughest conditions.

At SUPERIOR your plans, too, receive the careful attention and skilled workmanship that meets strict code and customer specifications. TRY SUPERIOR!

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SUPERIOR MANUFACTURING COMPANY

AMARILLO, TEXAS

Lewis Place, Tulsa, will give Warner Lewis Company almost 20,000 square feet of shop space for fabrication.

With the announcement of the new added facilities, Warner Lewis Company is now fabricating all types of non-ferrous metals including Monel, Inconel, nickel, aluminum, brass, stainless steel, silicon bronze, clad steel and alloy steels.

The Warner Lewis Company was organized in 1931 as a manufacturers' agent but the manufacturing of steel vessels was begun late in 1946.

Quaker Names Merkel, Klemm

Quaker Rubber Corporation, division of H. K. Porter Company, Inc., Philadelphia, has appointed J. J. Merkel and E. E. Klemm, branch managers of the Detroit and Cleveland districts, respectively.

Both Merkel and Klemm will assist the district managers in the operation of the sales office and warehouse.

Merkel has been associated with Quaker in a sales capacity since 1948 and has had previous experience in the rubber industry. He attended Detroit Institute of Technology and Wayne University.

Klemm has been a salesman with Quaker for more than three years, and is a graduate of Baldwin-Wallace College with degrees in Economics and Business Administration.

Anderson Returns to B&W Tube

James S. Anderson, who has been on leave from The Babcock & Wilcox Tube Company, has returned to his duties as assistant general sales manager with the company at Beaver Falls, Mass. Anderson has been in Washington serving as chief of the Tubing Section of the Iron and Steel Division of the Industries Operations Bureau of the National Production Authority since April, 1951.

Engineer Available

BSChE 1949 (cum laude), EE minor, 3 years USNR, age 26, personable, presently employed as process engineer, one year polymer development, one year petroleum process engineering, has inquiring and original type of mentality, proven creative ability. Has originated and developed to plant scale valuable petroleum process yielding over $300,000 per month—payout time of half year. Now developing another original and patentable process for same firm. Present salary does not reflect ability or results. Desire change due to lack of financial incentive. Desire foreign position (tax benefits) or opportunity for minor share of creative results. Wide field of interests. Available for interview late December. Box 107-R c/o Petroleum Refiner, Houston, Texas.

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Work in Southern California

Positions are open in the engineering and design of complete oil-refineries and chemical-plants. Our expanding workload presents opportunities for advancement.

Prefer mechanical engineers with experience in the design and drafting of high-pressure piping.

Please send a detailed summary of your education, experience, and personal history to our Personnel Department. Also include a recent photo of yourself. All replies will be kept confidential.

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Wanted—Sales Engineer

A large national and well established manufacturing organization of oil industry and industrial equipment has an opening for a sales representative to cover East Texas and South Louisiana. Age 30 to 40. Job will require approximately 75% of time traveling in the territory and within a year will require establishing residence in Louisiana. Oil field experience not necessary but helpful. Must have sales experience. Replies confidential. Our organization knows of this ad. In relying give full details, experience, present salary and any other pertinent information. Will contact for personal interview if you look like our man. Address Box 108-R, c/o Petroleum Refiner, P. O. Box 2608, Houston, Texas.

WANTED—Traveling Auditor

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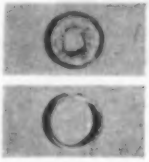
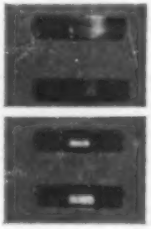


Section of pipe before and after descaling with Oakite Compound No. 32



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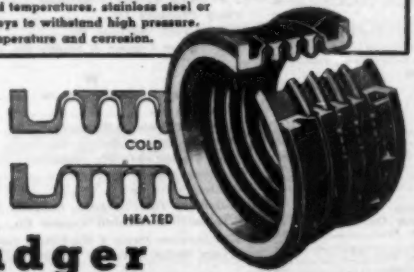

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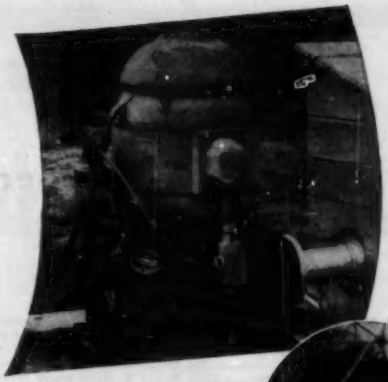

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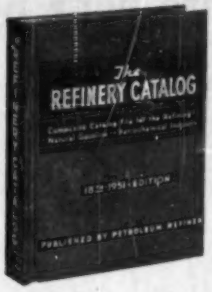

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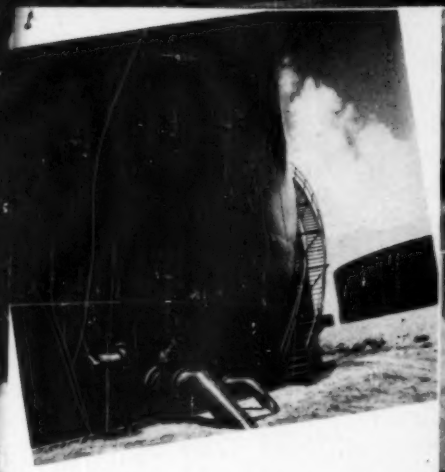

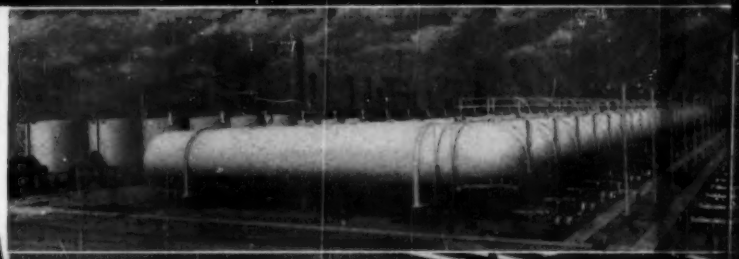

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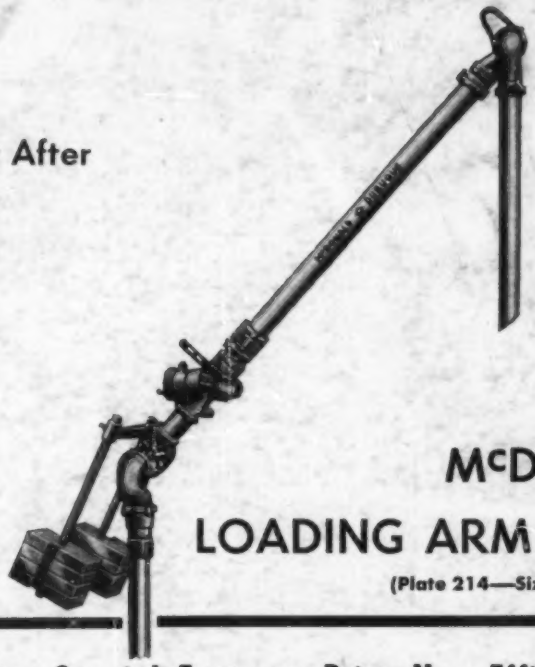

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